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# Contributions to Education

## Teachers College Series

# THE PROBLEM OF TEACHING HIGH SCHOOL PUPILS HOW TO STUDY

BY
JOSEPH SEIBERT BUTTERWECK, PH.D.

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J. S. B.

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# THE PROBLEM OF TEACHING HIGH SCHOOL PUPILS HOW TO STUDY

## CHAPTER I

### INTRODUCTION

#### WHAT IS STUDY?

An individual's concept of study is so bound up with his concept of education, and this in turn with his philosophy of life, that a definition of study is possible only in the light of his accepted aims of education. If one looks upon education as the rigorous disciplining of youth, necessary for the best preparation for life, the following definitions would no doubt be acceptable:

The object of study is to discipline the mind in all its parts.[1]

There is nothing of more use to the mind in the pursuit of knowledge than to be able to fix its attention steadily upon an object it has occasion to survey.[2]

If you read ten pages of a good book, letter by letter—that is to say, with real accuracy—you are forever in some measure an educated person.[3]

Or, if one conceives education as the storing up of a large amount of knowledge or information helpful in the pursuits of life, his definition of study might take the following form:

Study is the use of books for the serious purpose of gaining knowledge; it looks to a mastery of a subject—by means of what has been written about it.[4]

Or, if education is thought of as the solution of actual problems and thus school becomes "not only a preparation for life but life itself," then study is defined in still different terms:

It is the vigorous application of the mind to a subject for the satisfaction of a felt need.[5]

It refers to all the efforts to be made in order to find and apply the needed new response which shall relieve the difficulty situation.[6]

Whenever attempts are made to define study in any specific

[1] Todd, John, *The Student's Manual.* 1887.
[2] Clarke, John, *An Essay on Study.* 1737.
[3] Ruskin, John, *Sesame and Lilies.* 1864.
[4] Hinsdale, Burke A., *The Art of Study.* 1900.
[5] McMurry, Frank M., *How to Study and Teaching How to Study.* 1909.
[6] Kilpatrick, Wm. H., *Foundations of Method.* 1925.

terms, education itself is being defined as viewed by the one who is creating the definition. Our philosophy of education, however, is constantly changing as the experience of the world makes its impress on the philosophy of life dominant during any period. With this change there necessarily comes a change in our concept of study according as we are dominated by the philosophy of a Locke, Rousseau, Kant, Herbart, or Dewey. During any one period a great many different concepts of education are held, depending upon the heredity and environment of each individual.

Many who depend for their livelihood on our system of organized education seem to be without a conscious philosophy of education and attend to their daily tasks of "directing the destiny of youth" without themselves being able to state in any clear manner the "why" of the many duties that they require of their pupils. Such teachers are unconsciously practicing a certain philosophy of education which carries with it a corresponding definition of study. Every pupil of sufficient intelligence to maintain himself in this organized educational system adapts himself to the demands of the teacher, who finally passes upon his fitness to continue in school. This adaptation results in the formation of habits of study, which, for each pupil, serve as the path of least resistance to satisfy the requirements of the teacher, as the pupil views satisfaction.

In the light of these facts, there seems to be but one definition of study that fits into any and every possible school condition: Study is a pupil activity of the type required to satisfy the philosophy of education held by the teacher.

### WHAT HAS BEEN DONE IN THE PAST GENERATION TO DEVELOP IN PUPILS HABITS OF STUDY WHICH SATISFY THE CONCEPT OF STUDY HELD BY THE TEACHER?

The beginning of the twentieth century found a revival in interest in the study problem. The introduction of Herbartianism into this country focused activity on the improvement of methods of teaching. The result of method has its seat in the pupil; the pupil's activity in the preparation of the school's assigned task was therefore brought into question. Already pioneers were advocating a change in the aims of education from acquisition of knowledge to a something which had not yet taken on a definite form, but which at that stage might be referred to as the acquisi-

tion of habits and skills, or what Hinsdale termed "mental development."

*Approach through Assignment.*—In 1900 Hinsdale published his book, *The Art of Study*, in which he attacked the problem of study from the standpoint of the activities of the teacher in the classroom in making the assignment. He introduced three terms: "Study-Recitation," "Study-Lesson," and "Recitation-Lesson." The first comprised the activity of the teacher in taking the class through the steps in the assignment in the way the pupil would be expected to attack the lesson during his later study. It constituted the psychological approach in the assignment of the lesson. The "Study-Lesson" comprised the pupil activity in the preparation of the lesson developed in the "Study-Recitation"; and the "Recitation-Lesson" constituted the pupil-teacher relationship when the pupil reported back to the teacher the results of his "Study-Lesson" activities.

Hinsdale's contribution lies primarily in the fact that he insisted on regarding the activities of the teacher and the pupil as two separate activities with which educators must reckon and yet so related that the activity of the teacher must be regarded in the light of the later activity of the pupil. He really resorted to the type of relationship which existed between the Greek or Roman teacher and his pupil; the relationship was similar, but the activity differed.

Two assumptions, however, were made by Hinsdale which tended to vitiate results: (1) He assumed that the teacher was aware of the correct method of studying each type of study activity required in the preparation of the assigned lesson and therefore could make the assignment in the form in which the pupil would later engage in the study activity. The fallacy of his assumption is made plain by recalling that it has been since his book was written that we have most vigorously discussed logical vs. psychological method, direct vs. grammar method, inductive vs. deductive method, and that even to-day we have no worthwhile experimental study of the psychology of high school subjects except the one in Algebra by Thorndike and others. (2) Hinsdale also assumed that a teacher could present in the assignment the later study-pattern method of the pupil in a manner that would take care of the individual differences of the pupils and that would therefore result in the correct kind of activity in

the "Study-Lesson." This assumption was made before the day of a psychology of individual differences. An attempt to provide for this was no doubt made in his suggestion that

> before assigning the lesson for the next time the teacher should carefully inquire whether the pupils need assistance in preparing it and if the answer is in the affirmative he should furnish such assistance before they leave the recitation benches. Words in the lesson may need to be explained, points of difficulty to be set in a proper light, or important features to be pointed out.

Hinsdale, it will be noticed, was concerned with redefining the purpose of the recitation.

*Approach through a Redefinition of Study.*—During the first decade of the twentieth century McMurry was concerned with redefining study. But, as we showed before, a definition of study is purely relative, and McMurry's definition was made in terms of what has become known as the Dewey philosophy of education, analyzed from the standpoint of the method of a Herbartian.

However excellent his analysis of study, it lacks the motive power necessary to make it usable by the average teacher in the average classroom situation. His book, *How to Study and Teaching How to Study*, however, was heralded as an important link in the endeavor to solve the study problem and became the motive force for an extensive array of literature on "How to Study," a large part of which was an attempt to apply the McMurry steps to concrete study situations and thereby increase its value to the average classroom teacher.

*Approach through Supervision of Pupil Activity.*—Hinsdale's "Study-Lesson" and "Study-Recitation" suggestion bore fruit in an activity which perhaps has evoked more interest and has resulted in the creation of more pages of educational literature than any other one attempt to solve the study problem. The pupil failed to carry the assignment suggestion into his study activity and improve his study either because of a poor assignment or poor transfer ability or both. Supervision of the activity of the pupil during the "Study-Lesson" became the suggested solution and "Supervised Study" was given its propelling force.

What is supervised study and what is it accomplishing? We have no adequate study of the problem to make valid deductions, but the literature in the field is sufficient to indicate that the conceptions are many and varied, and the successes equally varied. A few progressive schools like the University of Chicago High

School have reconstructed their classroom procedure to such an extent that the classroom has become the laboratory in which the pupil works at his own problem under the supervision of the teacher. The old type recitation has been discarded, and group activity is replaced by individual activity at individual pupil rate, with individual mastery as the goal. At the other end of the scale we have the school which decides to adopt supervised study and accordingly splits a large study hall into smaller units in order that the teacher-policing during the study period may be more effective. It takes the form of efficient policing of study rather than supervision or direction of study. Between these two extremes we have many forms of a divided period or double period, during which part of the time is devoted to the old form of recitation, part to assignment, and part to a form of teacher-oversight of the pupil study.

At one end of the scale supervised study implies the scrapping of nearly all that, traditionally, has been dear to us—the group recitation; at the other end of the scale we retain all that has been handed down to us, but try to be more rigid in our enforcement of study requirements; and between these extremes we make various compromises.

Brownell [7] has collected into forty-five pages an evaluation of the literature on supervised study which appeared between 1910 and 1925. He has isolated from the literature fourteen different types of technique in use under the caption of supervised study. He shows that if two schools were to adopt the same type of technique, there still are at least "five factors sufficiently different in the two schools to make doubtful identity in procedure or in results." He further shows that if the two schools were practically identical in the five factors mentioned and were to adopt different types of technique, variations in the two systems to the extent of sixteen obvious factors would be possible. Furthermore, Brownell points out that if it were possible to standardize all of the foregoing twenty-one factors, and the two schools were to undertake an experimental study of the relative values of two types of technique of supervised study, there still are at least six factors in which the schools would differ sufficiently to tend to invalidate the conclusions drawn from the experimentation.

[7] Brownell, William A., *A Study of Supervised Study.* Bulletin No. 26, Bureau of Educational Research, University of Illinois. 1925.

Brownell also shows that the merits which are claimed for supervised study are not generally valid inasmuch as they represent the individual opinion of an enthusiast whose claim is consequently colored by his enthusiasm and is not based on evidence of the superiority of supervised study separated from other factors which make for successful teaching results, such as teacher ability and the like.

*Approach through Rules of Best Methods.*—One other type of attempt has been made in the last fifteen years to solve the study problem. What, specifically, are the rules which a pupil should observe when studying? Already a large collection of best methods had been accumulating as a result of the philosophers' introspection. These had been mentioned by Todd, Watts, and others. Experimental psychology had also developed some best methods of learning. The use of nonsense syllables developed the superiority of the whole method over the part method, and the superiority of spaced learning over unspaced learning. Interest in health improvement revealed the effect of certain physical defects —as in eye, nose, throat, humidity of air, etc.—on the learning rate of pupils. These three sources, together with the philosophy and experience of the writer, brought into existence in 1916 the Whipple thirty-eight rules of effective study. These also were accepted enthusiastically because they were definite in most part, and mandatory; in this form they could readily be placed into the hands of pupils for the improvement of their habits of study.

### EVALUATION OF THESE ATTEMPTS

Four different types of activities are therefore to be found which have as their aim the improvement of the study habits of high school pupils: (1) improvement of the assignment; (2) redefining study in the light of our modern philosophy of education; (3) supervision or direction of pupil activity during the period of study; (4) supplying a list of "best methods," or rules of procedure, which can be placed into the hands of the pupil. What are the implications of these attempts to improve study and what are the problems which arise from these implications?

A. Hinsdale's attack on study from the standpoint of the assignment as well as the attempt to direct the activities of pupils during their period of study assumes that the teacher knows the

correct or best steps which a pupil should use in his study for each type of study situation. The fallacy of Hinsdale's assumption has already been pointed out. Although the correct method of teaching a subject has been given considerable attention since 1900, we are not yet agreed on any one best method for teaching foreign languages, or mathematics, or science, or any of the high school subjects. A pioneer advocates a new method of teaching a subject—a method which he, as a master teacher, has found effective. But what has proved an excellent method in the hands of the super-teacher may prove a failure in the hands of the mediocre teacher. In the course of time another method supersedes the one which has been "tried and found wanting," and so on *ad infinitum*. No doubt the general level of teaching is gradually being raised through the different methods which are being tried, but to say that we have found *a method* of teaching any subject which when used in an assignment can be expected to parallel the activity which the pupil can later use with success in his study, is contrary to fact.

B. The Whipple rules, as well as the many variations of them which are found in high school handbooks, guides to teachers, and other forms designed to give teachers and pupils a list of best methods, are "logical deductions from general psychological principles rather than products of empirical data relative to study activities." [8] Even the experimental evidence from which some of these rules are deductions has been called into question lately, e.g., the value of the whole vs. the part method of learning. Their validity as sure and safe guides for action is therefore to be questioned.

C. The use of the Whipple rules as a solution of the study problem assumes that knowledge of facts translates into action, that knowing what to do is followed by the ability, as well as the willingness, to do. This is probably the case if two conditions are met: (1) if the task for which a particular rule is to be used is sufficiently motivated that it actually becomes a keenly "felt need"; (2) if the rule is so definite and specific that it leaves no doubt as to its application to the particular difficulty at hand. As these rules are usually presented in our high schools neither of these conditions is met; so that even if the validity of these

[8] Johnson, Roy, "Study Habits and Notetaking of Graduate Students," *School Review* 32: 293–99. April, 1924.

rules were beyond question their use as a solution of the study problem would not be likely to insure success.

D. McMurry's effort was directed largely toward a redefining of study rather than supplying a technique for teaching pupils how to study. Such suggestions as are made to get pupils to form better study habits seem to be based on the assumption that the solution of the problem lies in the improvement of the quality of teaching, and that improvement of the quality of the teaching would translate itself into improvement of the quality of the pupil activity during study.

E. Direction or supervision of study by the teacher assumes that the teacher can detect the presence or absence of the correct habit in study by simply observing the pupil, and, further, that this can be done for each of the twenty-five or thirty pupils under his supervision. This may be true when the activity is of a motor type, in which case the teacher observes the product of the pupil's mental activity and from this product judges the nature of the mental activity. This method can be used for some activities in mathematics, or when use of index, table of contents, glossary, or the like, is involved in reading or language translation; but when the mental activity does not express itself in a motor response, the product of which can be used to detect the nature of the mental activity, then the supervision of study as a means of improving study activities fails to function except in so far as the presence of the teacher may stimulate the pupil to activity.

*Knowledge Needed.*—A study of the four types of attack of the study problem mentioned heretofore reveals the absence of two types of information which are absolutely essential if either the assignment or the "supervision of study" method is to function properly in helping improve study habits of pupils: (1) Specifically and definitely, what *should* a pupil do when he is preparing a lesson in mathematics, history, French, and the like? Or even better, what should he do when he is solving an original in geometry, translating a sentence from French to English, getting the essential facts from a history lesson, reviewing for an examination in science? (2) Specifically and definitely, what *does* a high school pupil do when he is confronted by each of these problems of study? What does the successful pupil do? What does the unsuccessful pupil do? What does the successful pupil of high intelligence do? What does the successful pupil of low intelligence do?

*Progress Made.*—The answer to the first question must be given primarily by the philosopher and psychologist, and the latter, as was pointed out before, has hardly begun to answer the question. The second question or series of questions must be answered as a result of the collection, by the educational research student, of a large array of evidence to show the nature of the activities of pupils of various age, intelligence, and success levels, when confronted with specific study situations. (The University of Chicago High School has evolved five different study types, but the determination of these is not based on experimental evidence; their inclusiveness, then, as well as their independence, may be questioned.)

Little more than a start has been made in this field of research. A few questionnaire studies made during the last twelve years aimed to determine the nature of the physical factors which either helped or hindered study. These investigations were mainly concerned with showing that home conditions are not generally conducive to successful study. Giles [9] made such a questionnaire study of 258 high school pupils in 1914. Thorndyke [10] in 1920 attempted to find by the use of the questionnaire to 1,600 high school pupils the relative values of home and school study. These studies, however, revealed nothing concerning the pupil method of attack of a particular study task.

Rickard [11] in 1914 attempted to determine how a pupil attacked a definite assignment, using history for the eighth, tenth, and eleventh grades, botany for the ninth grade, and English for the twelfth grade. His study showed the number who, according to their own statement, read the assignment once, or reread it, using the dictionary, asked themselves questions, and so on. Webb [12] in 1920 used the questionnaire method of determining how 200 college students study psychology. Charters [13] in 1924 used the questionnaire method to determine how 258 college girls study a textbook assignment, how they memorize, what devices they use to concentrate, and what their attitude is toward notetaking.

[9] Giles, F. M., "Investigation of Study Habits of High School Students," *School Review* 22:478–84. 1914.

[10] Thorndyke, Elizabeth, "Environment as a Factor in Pupils' Study Life," *Education* 40:478–83. 1920.

[11] Rickard, G. E., "High School Students' Description of Their Methods of Study," *School Review* 22:673–77. 1914.

[12] Webb, L. W., "Students' Methods of Studying a Certain Subject—Psychology," *Journal of Educational Psychology* 11:193–206. 1920.

[13] Charters, Jessie A., "How Two Hundred Fifty-Eight College Women Study," *Journal of Educational Research* 11:41–48. 1925.

Mrs. Charters[14] also followed the previous study with an interview of 44 college seniors selected from among the poorest and the best in the class to determine in what respects the study habits of these two groups differed. Johnson[15] in 1924 used the questionnaire to determine the study habits of 52 graduate students in reading and notetaking. Deich and Jones[16] in 1923 used the questionnaire method of determining the study habits of the 316 best high school students in 315 Iowa schools. Certain interesting information was obtained in regard to taking notes, reading an assignment, reviewing, and distribution of time for study. This information is of value only in so far as the questionnaire with the leading question can be depended upon to portray facts as they really exist.

Most of these attempts have been on the college level, and only those of Charters and Deich took into consideration definite types of students—the successful and the unsuccessful. We must therefore conclude that we know very little concerning the study habits of high school pupils which we can use as information around which to build a program for improving study habits.

*Approach through Knowledge of Psychology of Habit Formation.*—A careful study of the four types of attempts made during the last twenty-five years to improve study practices reveals lack of consideration of a principle which is fundamental in habit formation. The psychologist tells us that habits are formed only through a repetition of the elements comprising the habit, and that the ease with which the habit is formed is determined by the degree of satisfaction attending the effort. This is nothing new, for at least the first part of this principle has been known ever since the Greek child learned to make its letters by drawing a stylus through a wax model of the letter to be learned. Locke accepted the principle when he wrote, "What you think necessary for them to do settle in them by an indispensable practice as often as the occasion returns." James popularized the principle through his laws of habit formation. Hinsdale accepted it when he wrote, "The child learns to read by reading," and "Habits come from practice."

[14] Charters, Jessie A., "Methods of Study Used by College Women," *Journal of Educational Research* 10:344–55. 1924.

[15] Johnson, Roy I., "Study Habits and Notetaking of Graduate Students," *School Review* 32:293-99. April, 1924.

[16] Deich, Charles and Jones, Elmer, "A Study of Distinguished High School Pupils in Iowa." U. S. Bureau of Education, *Bulletin*, 1923, No. 46.

However well this principle has been accepted and more recently written into the laws of learning, with the exception of our inadequate attempts at supervising study, it has been left out of our program of improving study habits.

### PROBLEM OF THIS INVESTIGATION

In any practical school situation the length of the teacher-pupil contact is fixed by certain administrative limitations. Therefore, the effectiveness of any technique or program for improving the study habits of pupils must take this limiting factor into consideration. Supervised study as a rule increases the teacher-pupil contact and, therefore, as Brownell has pointed out, introduces a variable which tends to vitiate the validity of a claim of superiority. Supervised study is also lacking a technique which can be handled effectively by the average teacher in the average school situation.

Is it possible to provide for study habit formation by giving controlled practice in the use of the elements involving the study habit and thereby making use of our psychology of habit formation and the laws of learning? And if so, will the result from the use of such a method be superior, equal, or inferior to that of acquainting the pupil with what he ought to do to be successful in a particular study activity provided the time element of contact between teacher and pupil is made constant?

# CHAPTER II

## EXPERIMENTAL SET-UP

### SELECTION AND EQUATING OF GROUPS

To attempt to answer the question raised at the end of the preceding chapter, the controlled experiment described in this chapter was undertaken.

Three equated groups of high school pupils were used, all of whom were subjected during the year to the same kind of classroom activity and held to the same standard of requirements. Two of these groups were exposed to two experimental factors, and the third group continued in its regular course, becoming the "control group" against which the effect of each experimental factor could be measured. The experiment was conducted at the Horace Mann School for Boys, Teachers College, Columbia University.

*Measures Used in Equating.*—Intelligence and studiousness were used as the measures for equating. Intelligence was measured by the use of the Terman Group Intelligence Test, Form A, given in December, 1924, and the Otis Self-Administering Test, Higher Examination, Form A, given in September, 1925.

No test for studiousness exists. Symonds[1] suggests the use of the sigma difference between intelligence and achievement as an objective measure of studiousness; a modification of this technique is used in this study. The use of objective achievement tests is suggested by him as the measure of achievement to be used. Standardized tests of such a type exist for some high school subjects, but their development on the high school level is still in its infancy. Their validity is therefore to be questioned as a measure of achievement directly resulting from school activities. Although such a test is more comprehensive than one teacher's examination, it is not so comprehensive as the sum total of all the teacher's examinations given throughout a school year.

[1] Symonds, Percival M., "A Measure of Studiousness," *Pedagogical Seminary and Journal of Genetic Psychology*, v. 32, 2:257–65. 1925.

School marks were therefore selected as a measure of achievement, not because they were considered wholly reliable, but because they appeared to be the best available measure.

*Selection of School Grade.*—Three factors were observed in determining the school grade to be selected for the experiment: (1)the longer a course is pursued, the more firmly fixed are the habits of study used; (2) school marks used as a measure of achievement must be comparable; and (3) courses pursued by pupils must be as similar as possible. (1) The first of these is obvious from our laws of habit formation. (2) Starch and Elliott, F. W. Johnson, Finkelstein, Rugg, Meyer, Dearborn, and others have supplied sufficient evidence to show that marks by a teacher in one school are not necessarily equivalent to similar marks given by a teacher in another school; that marks given by different teachers in the same school are more likely to be equivalent than those given by two teachers in different schools; and that the marks given by one teacher are more likely to be comparable than those given in either of the two previously mentioned situations. There is quite an influx of new boys at Horace Mann School at the beginning of the ninth grade. These new boys come from a great many different schools, each having its own standard of marking. This fact would therefore suggest the use of a school grade above the ninth. (3) The higher the school grade, the more heterogeneous the nature of the pupil schedules, for the greater the number of electives permitted. This raises the difficulty of selecting subject matter to be used in applying the experimental factors, if the higher grades are used.

The problem raised by the lack of comparability of school marks from different schools therefore necessitated the selection of those tenth grade boys who were doing regular ninth grade work the year before in Horace Mann School for Boys. There were sixty-two such boys in the fall of 1925.

*Making Scores Comparable.*—Considerable variation was found in the equality of teachers' marks, even for the same subject. If a pupil chanced to be taking a subject with a certain teacher a mark of 82 was found, as explained below, equivalent to a mark of 89 given by another teacher in the same subject. In some departments there was very little variation, but the marks of one department varied considerably from those of another department, i.e., a pupil receiving 82 in algebra and 73 in English would

have equivalent marks when measured in terms of the distribution of all marks given by two teachers in these two departments. Therefore, before averaging a pupil's marks in all subjects to get a measure of his achievement it was necessary to express the teacher's marks in comparable scores. The following method was used: All the final marks given by a teacher in all the subjects taught by him were expressed as deviates from the mean of the marks given by that teacher, and these deviates when added to five and multiplied by ten gave two-integer whole and positive numbers which will be referred to hereafter as the derived scores. These derived scores corresponding to a pupil's marks in a given subject were used as the final marks to be averaged to determine the achievement measure. A few samples will serve to illustrate the method. Teacher H was found to have given 200 separate final marks. These were distributed as shown in Table I, which

TABLE I

CONVERTING TEACHERS' MARKS INTO DERIVED SCORES

| Marks | TEACHER H | | | | TEACHER M | | | |
|---|---|---|---|---|---|---|---|---|
| | *f* | *n* | *p* | Derived Score | *f* | *n* | *p* | Derived Score |
| 95–99 | -- | ----- | ---- | -- | 10 | 143.0 | 96.6 | 68 |
| 90–94 | 6 | 197.0 | 98.5 | 72 | 30 | 123.0 | 83.1 | 60 |
| 85–89 | 16 | 186.0 | 93.0 | 65 | 31 | 92.5 | 62.5 | 53 |
| 80–84 | 34 | 161.0 | 80.5 | 59 | 27 | 63.5 | 43.0 | 48 |
| 75–79 | 62 | 113.0 | 56.5 | 52 | 22 | 39.0 | 26.4 | 44 |
| 70–74 | 69 | 47.5 | 23.8 | 43 | 18 | 19.0 | 12.8 | 39 |
| 65–69 | 6 | 10.0 | 5.0 | 34 | 2 | 9.0 | 6.1 | 35 |
| 60–64 | 5 | 4.5 | 2.3 | 30 | 5 | 5.5 | 3.7 | 32 |
| 55–59 | 2 | 1.0 | .5 | 24 | 1 | 2.5 | 1.7 | 29 |
| 50–54 | -- | ----- | ---- | -- | 2 | 1.0 | .7 | 25 |

*f*—number of marks per class interval.

*n*—number of cases below the marks represented by the class interval plus half those included by the class interval.

*p*—per cent of total number of marks given by that teacher included in that class interval in the *n* column.

illustrates the technique used in translating raw scores into derived scores. The table shows that the marks of teacher H from 75 to 79 are about equivalent to the marks of teacher M

from 85 to 89. The technique employed is essentially that which McCall[2] uses in creating a T score.

In order to average the Terman and Otis scores it was necessary to express these in comparable scores. The derived score technique was again used. By subtracting the average of the derived scores for intelligence from the average of the derived scores for achievement, a score is obtained which is used as a relative measure of studiousness. It represents the sigma difference score suggested by Symonds, and will hereafter be referred to as the *studious index.* For example, pupil No. 10 was given the following term marks by his teachers: English 80, French 75, history 79, Latin 77, algebra 75, and science 80; his Terman score was 155 and his Otis score 49. When these scores were translated into derived scores they appeared as follows: English 55, French 52, history 52, Latin 51, algebra 50, science 53, which resulted in an achievement average, expressed in derived scores, of 52. The derived score for the Terman test was 51 and for the Otis test 47, or an intelligence average, expressed in derived scores, of 49. Subtracting the intelligence score of 49 from the achievement score of 52 gave a studious index of + 3.

*Equating.*—Table II shows a twofold distribution of the sixty-two boys on the basis of intelligence and studious index. This table was used in equating the three groups. Pupil No. 19 has the highest studious index and next to the lowest intelligence score; pupils No. 60 and No. 61 fall next in order with regard to these traits. These three pupils were placed first in the three groups—No. 19 heading one group, No. 60 another group, and No. 61 the third group. The remaining pupils were similarly distributed so that those falling in each of the sixteen quarters of the distribution of Table II were divided as equally as possible among the three groups. Three of these boys, No. 25, No. 45, and No. 60, had to be eliminated during the first month because of schedule conflict or continued absence from school. Group A then comprised nineteen boys, Group B twenty, and Group C twenty. The extent to which these three groups are equal with respect to achievement, intelligence, and studious index is shown by a comparison of the means and standard deviations given in Table III. Group A shows a slight superiority in intelligence, but in other respects the means for averages and studious index are about

[2]McCall, William A., *How to Measure in Education.* Macmillan. (1922)

## TABLE II

### Distribution with Respect to Intelligence and Studious Index

| Studious Index Scores | Derived Intelligence Scores | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28–30 | 31–33 | 34–36 | 37–39 | 40–42 | 43–45 | 46–48 | 49–51 | 52–54 | 55–57 | 58–60 | 61–63 | 64–66 | 67–69 | 70–72 | 73–75 |
| 17–19 | | | 60 | | | | | | | | | | | | | |
| 14–16 | | 19 | | | | | 25 | | | | | | | | | |
| 11–13 | | 61 | 55<br>31 | | 20 | 24 | | | | | | | | | | |
| 8–10 | 51 | | | 1 | 29 | 35, 57 | | 58 | | | | | | | | |
| 5–7 | | | | | 7, 39<br>14 | | 4, 46 | 44 | | 5 | 26 | | | | | |
| 2–4 | | | | | 32 | 42 | | 10, 15<br>16, 30<br>35 | | | | | | | | |
| − 1 to 1 | | | | 34 | | | 9, 56 | 23, 37 | 8, 11,<br>41 | 6 | 43 | | 45 | 28 | | |
| − 4 to − 2 | | | 48 | | | | 2 | 21<br>54 | 13 | 50 | 3 | 40 | | | | |
| − 7 to − 5 | | | | | | | | 12 | | 33 49<br>50 | 47 | | 18 | | | 27 |
| − 10 to − 8 | | | | | | | 62 | | | 17 | | | 38 | | | |
| − 13 to − 11 | * | | | | | | | | | | | 22 | | | | |
| − 16 to − 14 | | | | | | | | | | | 53 | | | | | |
| − 19 to − 17 | | | | | | | | | | | | | | 52 | | |

Each number represents a pupil.

Q1 M Q3

equal. This difference is largely due to the effect of taking pupil No. 60—of highest studious index and lowest intelligence for his group—from the small number of pupils comprising group A. The other two pupils who had to be eliminated were located nearer the point of central tendency for their respective groups and therefore had less effect on the means of the group.

TABLE III

INITIAL DERIVED SCORES

| GROUP | ENGLISH | FRENCH | HISTORY | LATIN | MATHEMATICS | SCIENCE | ACHIEVEMENT AVERAGE | INTELLIGENCE AVERAGE | STUDIOUS INDEX |
|---|---|---|---|---|---|---|---|---|---|
| PRACTICE GROUP (GROUP A) | | | | | | | | | |
| Mean | 50.8 | 49.6 | 49.6 | 52.2 | 52.8 | 49.9 | 51.2 | 50.6 | 0.6 |
| S. D. | ---- | ---- | ---- | ---- | ---- | ---- | 5.4 | 8.0 | |
| P. E. $_{(mean)}$ | ---- | ---- | ---- | ---- | ---- | ---- | .83 | 1.24 | |
| NON-PRACTICE GROUP (GROUP B) | | | | | | | | | |
| Mean | 50.2 | 51.3 | 51.2 | 53.3 | 52.2 | 47.6 | 50.6 | 49.7 | 1.0 |
| S. D. | ---- | ---- | ---- | ---- | ---- | ---- | 6.9 | 9.3 | |
| P. E. $_{(mean)}$ | ---- | ---- | ---- | ---- | ---- | ---- | 1.05 | 1.40 | |
| CONTROL GROUP (GROUP C) | | | | | | | | | |
| Mean | 51.0 | 54.0 | 52.7 | 52.7 | 51.5 | 51.1 | 51.0 | 49.6 | 1.4 |
| S. D. | ---- | ---- | ---- | ---- | ---- | ---- | 7.9 | 9.8 | |
| P. E. $_{(mean)}$ | | ---- | ---- | ---- | ---- | ---- | 1.2 | 1.48 | |

EXPERIMENTAL FACTORS

Group C became the control group and did not meet the writer excepting occasionally for the purpose of testing, as will be mentioned later. Groups A and B each met twice a week for forty-five minutes, the latter on Tuesdays and Thursdays and the former on Mondays and Wednesdays. All experimental work was confined with a few exceptions to these two periods a week for each group.

Group B was given a course in best methods of studying, the material selected being taken from such books as Kitson's *How to Use Your Mind*, Lyman's *The Mind at Work*, Whipple's *How to Study Effectively*, Sandwick's *How to Study and What to Study*,

McMurry's *How to Study and Teaching How to Study*, and Dearborn's *How to Learn Easily*. The outline which was used as the basis for the work in Group B is shown in the Appendix. The order given in the outline was not adhered to, however, for it was found necessary to discuss best methods for reviewing for an examination during the month preceding the mid-year examinations, to devote special time to best methods for solving originals in geometry during the period devoted to practice in this technique by Group A, and to emphasize methods of reading and outlining when Group A was receiving practice material in "reading for the purpose of studying." At all times the writer aimed to relate the content of this course as closely as possible to the task which the pupils had in hand in preparing their daily assignment without actually using the content of next day's lesson for this purpose. Stated briefly, pupils of Group B were told how to attack their study in the hope that they would apply the suggestions to everyday practice. A more detailed statement of the procedure used is given in Chapters III, IV, and V.

Pupils of Group A were given no "best methods" suggestions. They were informed from time to time of the intent of the practice work to which they were subjected, but at no time did the class discuss "best methods," evolve rules of procedure, or make a conscious effort to recall how they had done this or that in class. The pupils were simply given practice material in the elements of certain study situations and just enough directions in the use of these materials to insure reasonable efficiency in their use. Endeavor was always made to create practice material that would be self-corrective so that the pupil would know the degree of proficiency attained by him in the particular operation at hand. Occasionally the distribution of the scores for the practice group was placed on the board in order that each pupil might compare his score with that of the group of which he was a part. This was used as a method of stimulation to greater activity.

Briefly, the experiment consisted of the following: creating three groups of pupils as nearly alike as possible in those factors which form the basis of school success as conceived in the average school to-day; permitting the control group to continue its usual study procedure; giving the non-practice group a course in best methods of study; and subjecting the practice group to a series

of practice material in study situations in which it was engaged throughout the year.

It should be mentioned at this point that the division of the tenth grade into groups for this experiment in no way coincided with the division into recitation sections for regular school work. Each class recitation section for each of the regular subjects pursued—English, geometry, Latin, French or German, and general science—contained boys from each of the three equated groups, so that no difference could be made in the way these groups were treated in their regular school work. The experimental work was therefore additional and did not supplant any of the routine school work.

# CHAPTER III

## THE SOLUTIONS OF ORIGINALS IN GEOMETRY

It should be remembered that in no case is the writer concerned with answering the question: What should a pupil do in a particular study situation? or What does he do in that situation? He is concerned primarily with determining which method of teaching a study habit will be most likely to instill in a pupil the use of that study habit.

However, before either experimental factor used in this study can be applied to a concrete study situation a study method must be selected which is likely to be attended by success. In the field of mathematics, for example, the experiment is confined to the solution of originals in geometry of the demonstrable type as contrasted with the type in which solution depends upon the use of algebra or arithmetic.

### HOW SHOULD ONE ATTACK AN ORIGINAL INVOLVING DEMONSTRATION?

Touton[1] critically examined 2,800 New York examination papers in geometry to determine an analysis of difficulties encountered in the solution of originals. He concluded that a pupil in the act of solving an original goes through five steps:

I. Identification of
   A. All given elements (facts or relations).
   B. Elements of the desired outcome (facts or relations to be proved).

II. Search for
   A. Direct outcome of each given element considered above, and apparent implications of the desired outcome.
   B. Situations (combinations of elements) which do or would involve known elements, or known elements and the desired outcome.

III. Selection of a certain situation because it involves most known elements or the potent elements which give promise of being useful in reaching the desired goal.

IV. Utilization of a situation and its outcomes as a new situation, etc., leading toward the desired outcome. This step includes or may include:

[1] Touton, Frank C., *Solving Geometric Originals*. Contributions to Education, No. 146. Teachers College, Columbia University. 1924.

A. The testing of a selected situation and its outcomes to reach the desired outcome, or

B. The testing and rejection as in B above, followed by drawing of construction lines, providing thereby a new situation which is then tested as in A and B above, etc.

V. Verification of conclusions:

. . . . . .

. . . . . .

C. Problems involving proof through syllogistic organization.

Perry[2] conducted an experimental study to determine the psychology of learning as applied to geometry and concluded that:

Student difficulties in the solution of exercises in geometry consist of the following:

I. Linguistic: statement, elements, relations between elements.

II. Analysis of facts into their elements.

A. Figure (basis for reasoning).

1. Complexity due to potency of words and phrases.
   *a.* As perpendiculars, bisectors, medians, producing sides.
   *b.* As types of figures.
2. Unfamiliarity due to inadequacy of connections.
   *a.* Relations between elements.
      (1) Number.
      (2) Obscuring of relations as overlapping figures and construction lines.
   *b.* Number of non-available, habitual responses, as diagonals connecting two bisecting angles of a quadrilateral; i.e., less recognition of partial identity of certain elements in the situation.

B. Reasoning—activity.

1. Selection.
   *a.* Rejected responses (neglecting relations or aspects of the figure).
   *b.* Accepted responses (from given relations, from possible conclusions).
2. Use of right relations.
   *a.* Number of essential steps—"purposive thinking."
   *b.* Detection of the crucial step or steps.
3. Drawing conclusions.
4. Judging conclusions—leading to bonds being strengthened, from satisfaction.

The writer proved several difficult originals and noted what he actually did mentally in arriving at a proof. He also gave the

[2] Perry, Winona M., *A Study in the Psychology of Learning in Geometry.* Contribution to Education. No. 179. Teachers College, Columbia University. 1925.

same originals to four teachers of geometry and asked them to note what they did mentally in arriving at a proof. Boys were observed in their study of geometry with a view of determining what the successful boy does as compared with the unsuccessful boy. Information as to the mental response to the geometry original stimulus was elicited by questioning several boys and noting differences between the response of the successful and that of the unsuccessful boy.

By combining these three types of information—(1) findings of experimental studies, (2) introspective observation of mental processes by experienced adults, and (3) observation and questioning of a few successful and unsuccessful boys actually engaged in studying geometry—the following study elements were finally determined upon as necessary for a successful solution of originals:

1. Identification of the given and the required as stated in the theorem.
2. Making oneself certain of the exact meaning of each significant word used in the theorem.
3. Selecting from the theorem those words or phrases which represent separate drawing operations and placing these in the order in which they have to be drawn.
4. Drawing the figure.
5. Recalling in terms of the figure what is to be proved.
6. Recalling to mind all facts developed in the past which might have any bearing on the desired proof.
7. Noting all the facts about the figure which are known to be true either because of the "given" or because of what follows directly from the "given."
8. Bringing the facts of element 6 to the figure (mentally), applying them to the unknown arising from element 5, determining their potency as leading to the facts of element 7, and discarding them or using them as they seem to give dissatisfaction or satisfaction.
9. The syllogistic organization of the facts finally selected in element 8.

Elements 2 and 3 developed from observing pupils at work. In some cases it was noticed that a boy either drew a figure incorrectly, or, having drawn it apparently correctly, made certain false assumptions because he had a vague or inadequate concept of a word expressing a geometric figure. A median, for instance,

might be interpreted as a midpoint of a side, or a line passing through the midpoint of a side, or a line drawn from the vertex to the middle of the opposite side, or a line drawn from the vertex perpendicular to the opposite side. This observation formed the basis for element 2.

One marked difference seemed to exist between the boy who was successful in drawing the figure and the boy who was unsuccessful. The successful boy methodically extracted from the theorem the words which represented separate drawing elements and drew one element before he extracted the other element, provided the drawing was difficult enough to challenge his ability. For example, "A diagonal of a parallelogram is trisected by the lines joining the other two vertices with the midpoints of the opposite sides"; the successful boy was likely to see that a parallelogram had to be drawn first; therefore he drew a parallelogram without at that instant being concerned with the rest of the theorem. Then he noticed that a diagonal was called for; he drew it. Next he might see that midpoints of sides opposite the other vertices are wanted and are to be connected with the vertices by straight lines. He selected the midpoints and drew the lines. In some cases he would seemingly combine two or three drawing operations into one, and then proceed to extract the remaining drawing operations from the theorem. The unsuccessful boy, on the other hand, either tried to create a mental picture of a completed figure, or he showed evidence of a confusion of the thoughts conveyed by the wording of the theorem. This, therefore, forms the basis for element 3 mentioned above.

### PROCEDURE

*Procedure with Group B.*—Four types of activities formed the basis for the instruction of the B group in the solution of originals: (1) discussion and development of "best methods," (2) demonstration in class, (3) the use of a series of questions to ask oneself as a basis of checking progress, (4) class discussion of how a particular situation should have been met.

(1) and (2) Activities (1) and (2) were developed together. A few of those pupils who were known to be successful in solving originals were asked to go through these solutions step by step at the board. They were encouraged to "think out loud" as much as possible. From these demonstrations the class with the aid of the teacher

developed the aforementioned nine study elements or steps of procedure which were finally put into the form of the six steps shown as the practice material for group A. Group B at no time was given systematic individual practice in the use of these study elements.

(3) The twelve questions used in Perry's study under the head of "Technique in Solution of Exercises in Geometry" were placed in the hands of each member of the class with instructions on how to use them.

(4) At the meeting following the attempt to solve the originals given in their regular geometry classes as mentioned under "Results" in this chapter, a few minutes were spent in pointing out the difficulties encountered and showing how the technique developed as a guide could have been used in overcoming that difficulty.

It was the writer's aim with group B to familiarize each pupil thoroughly with what constituted the "best method" of solving originals in geometry.

*Procedure with Group A.*—Each pupil was provided with a copy of the "Geometry Introductory Sheet" shown in the Appendix, as well as "Instruction Sheet A" containing five steps, and "Practice Sheet 1*a*" (or 1*b*, 1*c*, etc., depending on degree of advancement of the pupils' activity). The checking sheets shown in the Appendix (those used with "Practice Sheet 1*a*") were supplied as they were required. Pupils were instructed to read carefully the "Geometry Introductory Sheet" and then to proceed as directed. In addition to each pupil recording his own scores, the writer kept a record of the scores made by each pupil in each step for each practice sheet, and as a pupil showed indication that he had mastered the technique of a particular step—received perfect scores in that step for two or three consecutive practice sheets—he was instructed to omit writing out that step in the future.

One weakness of this technique soon developed; namely, that too much time was employed in giving a written response to a mental activity. Through a series of revisions this was finally replaced by "Instruction Sheet B" containing six steps and "Practice Sheet 1*m*" (or 1*n*, 1*p*, etc., depending upon the degree of advancement of the pupil) shown in the Appendix, with the checking sheets for that particular practice sheet.

In the opening paragraph of this chapter mention was made that the writer is not concerned in this study with determining

what a pupil should do in a particular study situation, but rather with the question of which method of teaching a previously determined correct study habit will be most likely to instill in the pupil the use of that study habit. Similarly, the writer is not concerned with developing the best practice technique to represent experimental factor A adopted in this study. He is concerned only with the use of a practice technique that proves to be successful enough to be operative for an arbitrarily selected study method which is a likely successful method for a particular study situation. For example, solving geometry originals is a particular study situation with which we are concerned in this chapter. The nine study elements selected as likely to be attended by success comprise a particular study method, perhaps not the best, but at least one for which we have sufficient experimental evidence, though not all of it is objective, to be assured of a fair degree of success. Its selection, however, is somewhat arbitrary for some of the elements mentioned or the order in which they are mentioned are subject to dispute. The practice technique here employed is also not necessarily the best; in fact a comparison of the first and second set of instruction sheets given in the Appendix shows that the techniques are different in certain essential details. The first set makes no provision for a systematic recall of facts of study element 7; the second requires their recall. The second set requires no motor response to all the facts of study element 6 but only to the fact which is likely to meet with satisfaction, whereas the first set requires the recall of at least some of the important facts of element 6 other than the one which will be attended by success.

The important thing in this study is that the experimental factor used with Group A consists of the use of some form of practice material which checks by means of a motor response the order in which the mental processes are employed in responding to a particular study situation, whereas the experimental factor used with Group B leaves to the pupil the translation of knowledge of correct method into action.

Pupils of Group A were subjected to a battery of self-corrective practice material in the study elements which had been previously developed as necessary to be successful in the solution of originals. It should be remembered that as soon as a pupil showed a marked proficiency in a certain step he was no longer required to express

in writing the response to the mental operation involved in that step. In general these practice steps were eliminated in the following order: 2, 1, 3, 5. Step 4, of course, is always necessary before step 6 can be undertaken, and so was seldom omitted even though proficiency was shown in it.

It will be noticed that three study elements among the nine adopted as necessary for a successful solution of originals have not been included in the practice material—elements 5, 6, and 9. Element 9 was omitted because a little exploration in requiring the writing of a syllogistic organization following a successful analysis for step 6 in the practice material revealed the fact that this gave pupils very little difficulty. They apparently had sufficient practice in the solution of propositions which had the syllogistic organization fully worked out in their textbooks that this became a simple process following a correct analysis. Study element 6 was omitted particularly in the second set of instruction sheets for another reason. This element is concerned with the mastery of the facts studied before. Any great amount of drill in this element would therefore be a drill in mastery of content in geometry and would be likely to influence success in geometry for reasons other than the acquisition of a habit of study. It was thought best to avoid this possibility if the omission of this element did not unduly decrease the ability to become proficient in the last step of the practice material. Pupils No. 3 and No. 9 (Group A) seemed to have difficulty in recalling facts embodied in element 6 and were encouraged to write out all the ways of proving the particular thing required to be proved, to apply them one by one and check them as the facts were used and found inadequate. The trouble seemed to be not so much a lack of knowledge of the facts as the inability to draw them out of the past and hold them in space (mentally) long enough to test them and then discard them and bring other facts to the fore. It was probably a lack of mental orderliness in such a situation. Study element 5 was omitted as a separate practice step because its recall is required as the initial recall in drill step 5.

## RESULTS

For a period of seven weeks, beginning with the middle of February, the pupils in their regular geometry classes were given six

different originals[3] to prove. These originals were selected by the writer and approved by the geometry teachers, and were new to members of the class so far as could be determined by the experimenter; at any rate, they were not in the textbook used by the class, nor had they been taken up in the regular classes; they formed no part of any of the drill work in experimental Group A, and were not referred to with Group B. Without previous knowledge of the fact, pupils were confronted on coming to geometry class with an original which they were asked to do as quickly and accurately as possible. It was previously agreed between the writer and the teachers that the amount of time to be allotted to working a particular original was to be determined by the length of time required for about eighty per cent of the class to complete its proof. Thus the length of time varied with the difficulty of the original, but was uniform for all pupils for a particular original.

The system of scoring used was that suggested by Perry and used by her in her study previously referred to. By the use of this method weighted credit is given for all the different operations required to be shown on paper in the writing out of the usual syllogistic organization, including the drawing of the figure and any construction lines necessary to effect a proof. When more than one proof was possible, it was found that one was always much more commonly used than the others. To have the same total possible score for both methods of proof the scoring for the less common method was adjusted to that of the more common method. This introduced a little more of the subjective element of scoring than was desirable, but it seemed to be the only thing to do, and in no case does the more subjective scoring affect the total score for a group to such a degree as to invalidate the results.

The method of scoring used as explained by Perry[4] is as follows:

1. Equal weight for drawing the figure, for statements of what is given and what is to be proved in terms of the figure, for placing of the figures and also the drawing of construction lines if required in the proof.
2. Figure, about ¼ of the proof score, usually.
   *a.* If simple, score 8 credits.
   *b.* If more complex (e.g., involving overlapping triangles), score 12, 16, or 20 credits.

[3] See Appendix.

[4] This method of scoring is too detailed to be practical and the credit assigned to steps too arbitrary to be defensible, but it was used because it seemed to be at least one step of improvement over the highly subjective method commonly used in scoring geometry proofs.

3. Steps in the proof.

| Nature of Step | Stated Correctly | Stated in Correct Order | Accompanied by Correctly Stated Reason | Total |
|---|---|---|---|---|
| Given | 1 | 1 | 2 | 4 |
| Link | 3, 4, or 5 | 3, 4, or 5 | 6, 8, or 10 | 12, 16, or 20 |
| Therefore | 2 | 2 | 4 | 8 |
| Therefore (derived) | 1 | 1 | 2 | 4 |

4. If the first "drawing conclusion" or the second one is correctly stated and placed and accompanied by the correct reason, but it does not follow from the preceding steps, subtract the total of that step from the proof score.

5. If two or more essential units (where the above scheme represents one unit in a proof) are involved, first weight each unit as above; then weight the total of each unit in the proportion indicated above if either or both are "link relations."

The application of this method of scoring to the first of the originals given for testing the final relative abilities of the three groups is shown in the Appendix.

TABLE IV

Scores in Geometry Originals

| | Original | | | | | | Sum of 1, 2, 3 | Sum of 4, 5, 6 | Total |
|---|---|---|---|---|---|---|---|---|---|
| | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 | No. 6 | | | |
| Highest possible score .. | 52 | 116 | 80 | 88 | 80 | 84 | 248 | 252 | 500 |
| Practice Group (Group A) | | | | | | | | | |
| Mean ..... | 47.3 | 73.8 | 57.7 | 59.7 | 48.6 | 65.0 | 178.8 | 172.8 | 351.6 |
| S. D. ..... | ---- | ---- | ---- | ---- | ---- | ---- | 51.0 | 52.6 | 92.0 |
| P. E. $_{(mean)}$ ..... | ---- | ---- | ---- | ---- | ---- | ---- | 8.1 | 8.4 | 14.6 |
| Non-Practice Group (Group B) | | | | | | | | | |
| Mean ..... | 31.4 | 40.2 | 52.3 | 44.9 | 42.3 | 58.1 | 123.9 | 145.3 | 269.2 |
| S. D. ..... | ---- | ---- | ---- | ---- | ---- | ---- | 43.6 | 64.2 | 111.0 |
| P. E. $_{(mean)}$ ..... | ---- | ---- | ---- | ---- | ---- | ---- | 6.5 | 9.7 | 16.6 |
| Control Group (Group C) | | | | | | | | | |
| Mean ..... | 34.5 | 43.0 | 39.9 | 45.8 | 35.4 | 50.7 | 117.4 | 131.9 | 249.3 |
| S. D. ..... | ---- | ---- | ---- | ---- | ---- | ---- | 69.2 | 57.7 | 114.6 |
| P. E. $_{(mean)}$ ..... | ---- | ---- | ---- | ---- | ---- | ---- | 10.7 | 8.9 | 17.5 |

Table IV shows the average scores obtained in each of the six originals for each of the three groups of pupils. Since the practice material given to the A group was confined entirely to Book I of geometry, and the last three originals were taken from Book II, a comparison of the relative scores of the first three originals and of the last three may be indicative of the extent to which the method transferred from one geometry situation to another. Pupils A-16 and C-20 were absent from school on account of sickness during the two months covered by this practice and testing, so that the averages given are for 18 pupils in Group A, 20 in Group B and 19 in Group C.

## CONCLUSIONS

Two types of evidence are likely to appear in such an experimental study: (A) that which follows directly from the resulting data which lend themselves to statistical treatment; and (B) that which tends to convince the experimenter or raise questions in his mind which have been suggested while handling the material used in the experiment but for which there are not sufficient objective data to draw scientific conclusions. Both of these types of evidence will be considered here.

(A) *Conclusions from Objective Data.*—A comparison of the mean scores of the three groups gives the following differences:

| Groups | Original Nos. 1, 2, 3 | Original Nos. 4, 5, 6 | Original Total |
|---|---|---|---|
| A exceeds B | 54.9 | 27.5 | 82.4 |
| A exceeds C | 61.4 | 40.9 | 102.3 |
| B exceeds C | 6.5 | 13.4 | 19.9 |

Are these differences due to chance or are they significant? Do they indicate that the experimental factors used had a real effect on the experimental groups in the ability to solve originals? Do they indicate that one of these experimental factors is superior to the other? To answer this question the usual statistical method for such cases is used—finding the Probable Error of the difference and determining the ratio of the actual difference to this Probable Error of the difference.

The following ratios of significance result from such a treatment of the data:

| Significance of | Originals Nos. 1, 2, 3 | Originals Nos. 4, 5, 6 | Originals Total |
|---|---|---|---|
| Excess of A over B | 5.2 | 2.2 | 3.7 |
| Excess of A over C | 4.6 | 3.4 | 4.5 |
| Excess of B over C | .5 | 1.0 | .8 |

When the ratio between the actual difference and the P. E. of the difference is 4 or more, the actual difference is usually accepted as highly significant. When such a ratio is 2 the odds are 4.6 to 1 in favor of an actual difference occurring at any one trial, and when the ratio is 3 the odds are 22 to 1.

From these data we can conclude (1) that the practice method had a significant effect in securing greater ability in solving originals; (2) that the non-practice method did not have a significant effect; (3) that in so far as success in solving the three originals selected from Book I and the three selected from Book II represent an ability to solve the originals in these two sections in geometry, the practice method had a greater and more significant effect in that part of the geometry in which actual practice was given; but (4) that its effect also transferred to the solution of originals of a different type from that in which practice was given. This seems to indicate that an actual ability was developed in pupils of the practice group (A) and that the effect of the practice extended beyond simply increasing the mastery of the facts which have to be used in solving originals.

A comparison of the standard deviations of the three groups indicates that Group A shows greatest homogeneity and Group C greatest heterogeneity in the ability represented by these scores. This raises the question as to whether the experimental factors used had different effects on different types of pupils. To answer this question the average score for each of four groups of pupils is given below—(*a*) those who rank in the lowest quarter for the whole class in intelligence, (*b*) those who rank in the highest quarter, (*c*) those in the lower half in intelligence, and (*d*) those in the upper half. Percentage of difference is used in order to make the results more readily comparable.

The data given below seem to indicate (1) that the practice method had its greatest effect on pupils of below average intelligence; (2) that its effect on pupils of high intelligence was practically nil, and the small negative difference for pupils in the highest quarter in intelligence raises the question whether the non-practice method is not better for pupils of high intelligence; (3) that the effect of the non-practice method is about equally divided between pupils of high and of low intelligence, although this difference is so small that it is probably not significant.

| | (*a*) Lowest 25 Per Cent in Intelligence | (*b*) Highest 25 Per Cent | (*c*) Lower Half | (*d*) Upper Half |
|---|---|---|---|---|
| Group A | 325 | 355 | 341 | 363 |
| Group B | 192 | 393 | 210 | 329 |
| Group C | 152 | 339 | 199 | 305 |
| Per Cent of Difference | | | | |
| A compared with B | 69 | − 9 | 62 | 10 |
| A compared with C | 114 | 5 | 72 | 29 |
| B compared with C | 26 | 16 | 6 | 8 |

We do not, however, have sufficient evidence to make the sweeping statement that the method to be used in teaching pupils how to solve originals is a function of the intelligence of the pupil, for this difference may be due to one or more of the following reasons:

*a*) The upper group in intelligence may need a different type of practice material; their habits of work may be different.

*b*) The upper group, through the fact that their neural structure is conducive to form this habit without the aid of externally imposed practice material, possibly had already reached the point of proficiency where the law of diminishing returns had set in. This condition would not, therefore, exist if the practice material were introduced earlier in the course and continued only until the correct habit of work is used.

*c*) The practice method may be attended by a concomitant learning that results in a disadvantage to the upper group. This

concomitant may be due to an aversion by this group to the routine incident to drill, although this is purely a supposition for which there is no experimental evidence.

*d*) The material used for testing the effect of the experimental factors may have been too easy for the upper group, so that any difference in proficiency due to the experimental factors could not be discerned with the measures used.

The writer is inclined to favor reasons (*b*) and (*d*). This opinion is based on the observation of the use of the practice material by some of the best pupils as well as observation of their work with originals without the use of the practice material. Pupils in this upper group seemed to follow the same general steps, but were so proficient in their use that they combined steps, particularly when confronted with originals which did not challenge their ability.

(B) *Probabilities, the verification of which requires further experimentation.*

(1) Group A, the practice group, seemed to experience considerably less difficulty in drawing figures. This is partially shown in the results for drawing the figure for original No. 1, which was probably the most difficult drawing to make from a verbal statement of the theorem. Only one pupil in Group A failed to draw this figure correctly; six failed in Group B and five in C. Pupils in Groups B and C also showed a greater difficulty in this respect with some of the other originals, as indicated by the greater number of incorrect attempts before the correct figure was drawn. For example, in attempting to draw figures for originals Nos. 3, 5, and 6, a total of nine papers in Group B and thirteen in Group C showed two or more figures or parts of figures drawn in order to get the correct figure, in each case crossing out the first drawing or in some other way showing that it was not to be used in the proof. This happened with only three papers in Group A for the same three originals.

(2) The number of useless statements made by pupils in Groups C and B was considerably greater than those made by pupils in Group A. For example, in proving originals No. 5 and No. 6 several pupils drew radii of circles or other lines which at first sight seemed to afford a method of proof. The pupil then referred to certain facts that were true because of the construction line, such as "arcs equal because central angles are equal,"

and the like, and then apparently seeing that this approach led nowhere, did not attempt to use these facts in further developing the proof. Although no actual number of cases can be given to substantiate this statement, the writer feels certain that this tendency was negligible in the A group as compared with Groups B and C.

(3) The syllogism of the proof was much better organized by pupils of Group A. This was particularly evident in original No. 3, in proving which it is necessary to prove certain relationships of triangles in the lower part of the figure before the two small triangles at the vertex can be proved congruent. Pupils in Groups B and C were much more likely to state certain known relationships in the upper figure, then state known relationships in the lower figure, and then go back again to the top figure to supply the facts necessary to complete their original statements. Correcting these papers led the writer to believe that pupils in Groups B and C were less likely to have worked out mentally the necessary steps in the proof before writing them down than was the case with pupils of Group A. Apparently pupils in Group A had a more definite plan in mind before resorting to the syllogistic organization. (It should be remembered that Group A was given no drill in the syllogistic organization, and, therefore, no improvement in this ability can be credited to specific drill, but an explanation must be sought in other activities.)

(4) In proving originals like No. 2, in which the pupil was faced with the need of a statement for which he did not know the reason, pupils in Group A were likely to resort to a statement similar to the following: "If I could get line $AB$ equal to $CB$ I could prove angle $A$ equal to angle $C$." Not knowing just how this was possible the pupil continued with the proof to a satisfactory conclusion with the reason for this step left out. This again indicates a systematic planning which did not show itself in this manner to any marked degree by pupils in Groups B and C.

(5) Pupils in Groups B and C made false statements which seemed to arise from apparent relationships due to the manner in which the figure was drawn. A line might be referred to as a perpendicular because it looked like a perpendicular, when, instead, it was given as a median. This is probably due to the emphasis in the practice material on the inadvisability of drawing regular figures when a general figure would satisfy the conditions of the theorem.

SUMMARY OF CONCLUSIONS

The following seems to be suggested, but its actual proof requires further empirical evidence:

The practice method as defined herein—

1) is more likely to insure the use of the method which is considered the "best method" than is instruction of the type usually employed for class groups—demonstrating to the class how it should be done—when the aim is to develop skill in solving originals;

2) is more likely to insure mastery of the facts required in the solution of originals;

3) is more likely to reduce the range of trial and error in the solution of originals;

4) secures a better attack in translating the written theorem into a geometric figure;

5) insures a better organization of the syllogism which is usually referred to as the geometric proof;

6) results in a better planning or analytic thinking which precedes the syllogistic organization;

7) reduces the proving process as a trial and error response and increases the tendency toward a thoughtful planning response.

The following is evident from the data at hand:

When ability is measured in terms of the resulting product rather than the method used in getting that product, the practice method as defined herein—

1) is decidedly better than simply apprising pupils of the "best methods" as a means of teaching pupils how to solve originals;

2) seems to increase in superiority with a decrease in the intelligence of the pupils with whom it is used;

3) does not seem to be better for pupils of highest intelligence, and perhaps not as good as the demonstration method.

# CHAPTER IV

## REVIEWING FOR AN EXAMINATION

### WHAT SHOULD ONE DO IN REVIEWING FOR AN EXAMINATION?

A survey of the literature on the subject reveals the fact that most of what has been written on examinations deals with certain physical aspects, such as having "at least two fountain pens well filled and clean," being careful that the room is amply ventilated and at the best temperature, taking plenty of sleep, avoiding heavy foods, and the like. Or the often reiterated warning is given that with conscientious day-by-day preparation "the examinations will take care of themselves," a warning which is probably heeded by a negligible percentage. Very little space is given to a discussion of what, concretely, to do in bringing together and organizing most effectively the many stray and seemingly unrelated facts and ideas which have come into the student's school life during a month, or a half year, or a year preceding an examination. One author who devotes ten pages of a book on how to study for examinations covers the topic of reviewing for the ordeal in about one page. Another author in a chapter on "examination preparedness" devotes eighteen pages to a discussion of the importance of keeping notes posted up to date, values of examinations, the merit of oral vs. written examinations, what to do while taking an examination, etc., and gives about half page to a paragraph of which the gist is "a student sometimes gains much by looking over the entire material of the examination immediately before the examination hour."

We have no experimental study on the subject; therefore whatever plan is used in acquainting pupils with the best methods to be used in reviewing for an examination must be based on the few stray suggestions taken from books on how to study, a general knowledge of psychology and pedagogy, and introspection while in the act of preparing for an examination.

Accepting the thesis that reviewing for an examination comprises a reorganization of subject matter already learned, the

writer set out to review the contents of the general science and geometry which the tenth grade boys of Horace Mann School would be asked to include in their midyear examination.

*Procedure in General Science.*—Skimming through the nine chapters to be included in the examination, it was finally noted that all could readily be placed under five heads. These five topics were placed on five lines headed by Roman numbers I to V. An effort was made to select the main subheads for each of the five topics, each topic considered separately, and to place these after the capital letters of the alphabet under the proper Roman numbers. This subdividing was continued until all important separate facts were included in the outline. When the task was completed, revised, and submitted to the science teacher to check up on facts stressed and omitted in class a form of outline was at hand, part of which is reproduced below.

OUTLINE FOR GENERAL SCIENCE REVIEW

I. Atmosphere
II. Heat
III. Oxidation
IV. Foods
V. Electricity

IA. Moisture in —
B. Pressure of —
IIA. Transmission of —
B. Expansion and construction resulting from —
C. Measurement of —
etc., etc., etc.

---

IA. 1. How it gets in (evaporation).
2. How it gets out (condensation).
B. 1. Relation to pump and siphon.
2. Measurement of —.
3. Effects of elevation on —.
4. Effects of heat on —.
5. Relation to winds and weather.
6. Relation to boiling point.
etc., etc.

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IA. 1. *a.* Sources of water for —.
(1) Bodies of water.
(2) Breathing of animals and plants.
(3) Soil.
*b.* Factors affecting rate of —.
(1) Heat and wind.

*c.* Effects of.....(cooling).
(1) Use in ice manufacture.
(2) Use in iceless coolers.
(3) Relation to health and comfort.
(4) Humidity (relative).

2. *a.* Near the earth.
Dew, frost, fog, mist.

*b.* Away from the earth.
Clouds, rain, hail, snow, etc., etc.

This, it will be noticed, is not so logically arranged as one usually expects to find an outline, but we are not concerned in this case with logical arrangement; we are concerned with putting into writing the results of the thought processes involved in a thorough review of previously learned facts. An effort was made to check this with pupil practice, by asking some of the most successful boys as to the procedure they use in reviewing for their general science examination, but each boy interviewed either minimized the need for a thorough review or simply leafed through the book, refreshing his mind on the separate facts there recorded. There seemed to be no attempt, even among the most successful boys, to view facts in their relationships—an element of reviewing usually pointed out as its chief value.

During the process of making the outline for review the writer noticed that several instruments for measuring forces or phenomena were mentioned. He therefore tried to extract these from the outline and list after each the particular force or phenomena measured: e.g., atmospheric pressure—barometer; temperature—thermometer; amount of electrical current—ammeter; etc. Certain units of measurement were also mentioned. These were collected into one list: e.g., unit for measuring temperature—degree (*C* or *F*); quantity of heat—calorie or B. T. U.; amount of electric current—ampere; etc. The names of certain scientists were mentioned, each connected with a particular discovery. These, associated with their discoveries, were collected into one whole as follows: making first barometers—Torricelli; first thermometer—Galileo; generation of static electricity—Volta; etc. A rather large number of new scientific words were also met in the review. These were collected into one list, particularly if there was a question as to their exact meaning, or a possibility of confusion with another similar word, as latent heat and specific heat, etc. A number of bits of apparatus were met which were associated

with certain phenomena. These were collected: e.g., iceless cooler —cooling effect of evaporation; thermos bottle—vacuum is a non-conductor of heat; electric motor—attraction and repulsion of magnets; dynamo—current induced by cutting lines of force.

It will be noticed that in this review the writer aimed to view facts in their relationship with each other—with similar and dissimilar facts—rather than in the logical order in which they were arranged in the textbook and had been studied originally.

*Procedure in Geometry.*—Again the writer was forced to use adult introspection as the basis for determining a method for review of the first two books in geometry, for neither educational literature on the subject nor the practice of successful pupils threw any light on the problem. A conference with the geometry teachers as to the activities in the classroom that had been stressed during the term provided some help.

The following method was finally adopted by the writer as an adequate review:

1. Listing all geometric concepts developed—median, rhombus, etc.
2. Collecting into one unit certain relationships frequently used in proofs.
   - *a.* Conditions of congruency of triangle.
   - *b.* Ways of proving lines parallel.
   - *c.* Ways of proving lines equal.
   - *d.* Ways of proving angles equal.
   - *e.* Ways of proving triangles isosceles.
   - *f.* Ways of proving quadrilaterals parallelograms, etc., etc.
3. Ability to associate the correct figure and its construction lines with its theorem.
4. Dividing propositions into three groups—those emphasized in class as highly important (teacher had starred certain propositions for the class), those omitted entirely or not considered important, and all others.
5. Examining each proposition and corollary of the last group in (4) to try to recall the key reference or references around which the proof is built.
6. Actually going through the syllogistic proof of the first group in (4) with only the figure as a guide.

### PROCEDURE WITH EXPERIMENTAL GROUPS

### *Group B*

The three weeks preceding the midyear examination was devoted to review with special emphasis on general science and geometry. One period of forty-five minutes was devoted to a

discussion of the chapter in Kitson [1] which deals with preparation for examinations. Two periods each were devoted to developing a method of review for general science and for geometry—the method developed in each case being the one used by the writer as mentioned in this chapter. The last period was devoted to a general review of the discussion of the first five periods.

Both the general science and the geometry books were used freely in illustrating the method of reviewing advocated, but there was an avoidance of a methodical review by the use of the text, similar to the method used by Group A.

### *Group A*

Stated briefly, Group A was taken through the procedure in reviewing which was explained in the early part of this chapter, each pupil proceeding at his own rate.

*In General Science.*—Each member of the class was given a copy of the "Instruction Sheet for General Science Review" (see Appendix). Following a short group discussion which was aimed to clear up difficulties that might arise, each pupil with the use of his general science book and the written instructions, proceeded to outline the nine chapters to be included in the review. The writer went from pupil to pupil, noting the response to the instructions and giving aid and suggestions when this seemed feasible. This was found necessary until the class was well under way. One general error was noticed at first. Pupils were likely to rely too much on paragraph and section headings as the basis for the divisions rather than on the ideas contained therein. The particular book used abounded in prominent paragraph and section headings, but the material was more poorly organized than is usually the case in textbooks; the organization in places was more that of a compendium of information than the development of scientific ideas or concepts. A general warning on the point, accompanied by a concrete illustration, was given as an aid in overcoming the difficulty.

About one and one-half periods were devoted to this procedure. Another half period was used in having each pupil compare his own results with that of the writer—a mimeographed copy of which was provided—and making such corrections in his own as the pupil saw fit to make.

[1] Kitson, Harry D., *How to Use Your Mind.* 1916.

1908

There was a big difference in the percentage of the material actually covered in the period and a half. A few finished; some had done less than half; but each pupil was required to stop that part of the work at the end of the second period. He was permitted to keep his own outline, but returned the mimeographed copy given him. No system of checking or scoring similar to that used in the solution of originals was employed; the checking of the activity of the pupil rather took the form of supervision of the activity in the classroom plus an inspection of the pupils' papers between class periods, and in a few cases requiring pupils to make changes or even to repeat the whole operation. The value of the outlining, it must be remembered, was not the finished product—the outline—but the mental processes involved in producing it.

By the use of his outline and the textbook each pupil in Group A spent the third period selecting the different units of measurement found in the nine chapters, the names of the instruments of measuring forces or phenomena, and those other facts which can be related and studied under one head mentioned in the early part of this chapter. The lists of facts required to be selected were placed on the board, and the checking of the activity of the pupil again took the form of teacher inspection and supervision. This was made easy because of the need of a motor response to a significant mental operation—the pupil was required to write down each fact selected.

*In Geometry.*—Instructions written on the board required each pupil to find for himself and study four conditions of congruency of any triangles, two conditions of congruency of right triangles, seven conditions for proving angles equal, five for proving lines equal, six for proving lines parallel, two for proving triangles isosceles, five for proving quadrilaterals parallelograms, and angular values for triangles, quadrilaterals, and other polygons. No time was spent on a review of geometric concepts, for it was assumed that most of the class were quite familiar with these, and it would therefore be more profitable to spend the time on other facts.

After a pupil declared himself to be satisfied that he knew the conditions of congruency, etc., which he was requested to study, he was given a set of questions requiring the recall of these facts. A checking sheet permitted him to check his own work and arrive at a percentage score. The chief purpose of this quiz was to assure

a more careful review than might have been the case if the writer used no method of checking on these results.

As each pupil completed this checking, directions on the board asked him to leaf through Book I of his textbook and refresh his mind on the association of a figure with its theorem, placing particular emphasis on those propositions which have very nearly the same kind of figure and cases in which one theorem is a converse of the other. A set of eleven theorems was placed in the hands of each pupil as soon as he was satisfied with his previous study, with the request that the figure for each be drawn without reference to the book. A checking sheet was provided for this operation and a percentage score recorded.

Pupils already had certain propositions starred as important, this having been done in their regular geometry classes. They were then asked to select those propositions which in their opinion were so unimportant that they would not be given in a midyear examination, and to place a zero above the theorems of these. Each pupil then had three types of propositions and corollaries—starred important ones, zero unimportant ones, and those unmarked.

Pupils were asked to prove without the use of the book those propositions that were starred, and to recall the key reference or references for all unmarked propositions or corollaries. No attempt was made by the writer to determine the thoroughness with which this was done, except as could be determined by observing the activity of the pupil.

This review in geometry was confined to Book I, whereas Book II was included in their midyear examinations. An extra-school activity conflicted with one of the three periods intended for the geometry review so that only two periods could be devoted to the work, and most of the members of the drill group did not complete the review in class.

### RESULTS

The midyear examination in general science consisted of two parts. One part comprised a combination true-false and completion test of 85 separate responses, and the other part consisted of four questions of the essay type. The score for the true-false completion test consisted of the total number of correct responses made. The score for the essay part consisted of the total correct,

different, unit statements given by the pupil in answering the questions. These were determined as follows:—each question was first answered by the writer in such a way as to give each correct unit statement a single credit; e.g., in explaining the operation of a lift pump a statement that a valve in the piston opens upward would be regarded as one unit statement. Sixteen different unit statements were assigned to the lift pump question.

Similarly eighteen statements were assigned to the second of the essay questions, ten to the third, and eleven to the last question.

Table V shows the average scores for each of the three groups. The distribution of the scores in the form of teachers' marks for the midyear examination in geometry is also given in Table V. These marks represent a subjective opinion of the teacher marking the papers; no objective standard was used, nor was there a previous agreement between the two teachers who marked the papers as to the amount to be deducted for each type of error.

An examination of the papers by the writer with an attempt at a more objective scoring, however, did not result in any score that was relatively markedly different from the one given by the teacher; therefore the teachers' marks were used instead of the marks from a more objective scoring.

TABLE V

SCORES IN MIDYEAR EXAMINATIONS IN GENERAL SCIENCE AND GEOMETRY

| | PRACTICE GROUP (GROUP A) | | | NON-PRACTICE GROUP (GROUP B) | | | CONTROL GROUP (GROUP C) | | |
|---|---|---|---|---|---|---|---|---|---|
| | *a* | *b* | *c* | *a* | *b* | *c* | *a* | *b* | *c* |
| Mean | 63.4 | 26.4 | 77.1 | 59.6 | 22.4 | 78.5 | 54.0 | 19.7 | 76.5 |
| S. D. | 8.8 | 7.3 | 10.8 | 9.2 | 6.2 | 10.7 | 13.4 | 7.9 | 12.1 |
| P. E. $_{(\text{mean})}$ | 1.4 | 1.1 | 1.7 | 1.4 | .9 | 1.6 | 2.0 | 1.2 | 1.8 |

*a*—Science true-false test scores.
*b*—Science essay test scores.
*c*—Geometry examination scores.

## CONCLUSIONS

Only those conclusions which follow directly from the statistical treatment of the objective data will be considered for this study situation—reviewing for an examination.

A comparison of the effect of each of the two experimental factors and the significance of this effect can be more clearly seen by examining the following differences in means. (Significance, as in the preceding chapter, is determined by dividing the actual difference by the P.E. of the difference.)

| Group | Differences in Group | | Means |
|---|---|---|---|
| | Science T-F | Science Essay | Geometry |
| A compared with B | 3.8 | 4.0 | −1.4 |
| A compared with C | 9.4 | 6.7 | .6 |
| B compared with C | 5.6 | 2.7 | 2.0 |
| | Significance of Differences | | |
| A compared with B | 2.0 | 2.7 | .6 |
| A compared with C | 3.9 | 4.1 | .2 |
| B compared with C | 2.3 | 1.8 | .8 |

*General Science.*—If groups as a whole are considered—

1. The practice method is shown to have had a marked effect in reviewing for the examination in science as measured by both types of tests. This effect is also significant to the extent that its probability of occurring is at least 142 to 1.

2. The non-practice method has had a considerably smaller effect and its significance is also considerably less, the odds of its probability of occurring being only 5 to 1.

3. The practice method is shown to have a superiority over the non-practice method which is greater and more significant than the actual effect of the non-practice method itself.

*Geometry.*—There is no marked effect of either experimental factor on groups as a whole. This may be due to any of the following reasons:

1. The time spent on the review was not long enough to have had a measurable effect.

2. The best method for review for this subject was not used.

3. The measure used (the examination) did not adequately measure the ability of the pupils in the subject.

The writer is inclined to find the reason for a lack of difference in all three of these reasons and not merely in one of them.

*Effect on Pupils of Different Intelligence Levels.*—To indicate the differences in the effect of the experimental factors on pupils of different levels of intelligence, the mean scores for each of four groups of pupils are given below for the two science tests—(*a*) those who rank in the lowest quarter for the whole class in intelligence, (*b*) those who rank in the highest quarter, (*c*) those who rank in the lower half in intelligence, and (*d*) those who rank in the upper half.

| Group | Mean Scores | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Science True-False Test | | | | Science Essay Test | | | |
| | (*a*) | (*b*) | (*c*) | (*d*) | (*a*) | (*b*) | (*c*) | (*d*) |
| A | 61 | 64 | 62 | 65 | 26 | 27 | 25 | 27 |
| B | 56 | 70 | 56 | 64 | 17 | 28 | 19 | 25 |
| C | 48 | 65 | 47 | 60 | 16 | 25 | 17 | 23 |
| | Percentage of Difference | | | | | | | |
| A compared with B | 8.9 | −8.6 | 10.7 | 1.6 | 53.0 | −3.6 | 32.0 | 8.0 |
| A compared with C | 27.1 | −1.5 | 32.0 | 8.3 | 62.0 | 8.0 | 47.0 | 17.0 |
| B compared with C | 16.7 | 7.7 | 19.1 | 6.7 | 6.2 | 12.0 | 12.0 | 9.0 |

The only differences which show a high degree of significance are those which apply to pupils in the lowest 25 per cent and the lower half in intelligence, and in each of these cases the effect of the practice method is considerably greater than that of the non-practice method.

Our data therefore show: (1) that the practice method had a decided effect on pupils of below average intelligence; and (2) had very little effect on pupils of above average intelligence; (3) that the non-practice method had a slight effect on pupils of below average intelligence; and (4) in all cases but one an even smaller effect on pupils of above average intelligence; (5) that the practice method was superior to the non-practice method in all cases affecting pupils of below average intelligence; but (6) the non-practice method shows a superiority over the practice method

for pupils in the highest 25 per cent in intelligence; this difference becomes slightly in favor of the practice method when all pupils of below average intelligence are included. These differences, however, are small and not significant.

### COMPARISON OF RESULTS SHOWN IN CHAPTERS III AND IV

If the results of the use of our experimental factors—systematic practice and no systematic practice—are compared as they are employed in the study situation of the preceding chapter and the study situation of this chapter, one difference is discernible. The superiority of the practice technique over the non-practice technique is much more decided for pupils of below average intelligence as applied to the solution of originals in geometry than as applied to reviewing for an examination in science. This raises the question as to whether the method to be used in giving instruction which has as its aim the formation of correct study habits is a function of the study situation—whether a technique such as is used in the practice method is better for certain kinds of study than for other kinds of study. We cannot answer this question with the data at hand. However, certain differences stand out clearly to the experimenter which tend to explain why systematic practice shows a greater superiority in the solution of originals than in reviewing for an examination in science:

1. The practice technique employed for geometry originals is much more definite and specific than that employed in science review. This leaves a great deal less to the initiative of the pupil and therefore tends to favor the pupil with lower intelligence. In the practice technique employed in Chapter III the pupil is trained to think through a study element and then give motor expression to that element; then he proceeds through the next element in a similar manner, and so on until he has completed his task. When he is finished he has a definite check on his work and can profit by his mistakes. In the practice technique employed in this chapter his directions are more general and his response much greater in length before a check is provided for his work.

2. A much greater amount of repetition results in the use of the practice technique with originals in geometry. A pupil applies the same six steps to each of a great number of different originals. Although the facts used with the different originals differ, the method of procedure in the use of these facts is essentially the

same. Such a succession of repetitions is much more likely to develop a skill in the use of the elements in the study situation than is the case when repetitions are few in number, and the completion of one repetition requires a considerable length of time. The last is true of the use of the practice technique employed in reviewing for the science examination.

3. The method to be used in reviewing for an examination finds the pupil on a relatively higher point of his learning curve than does the method to be used in solving an original in geometry. These pupils have reviewed for examinations for a number of years, not in science, but in allied subjects like geography and history. What a pupil does or does not do in preparation for an examination is therefore pretty well a fixed habit by the time he gets to the tenth grade. Demonstrative proof in geometry is a new study situation. Therefore, in the former study situation a pupil is quite likely to be found on the plateau of his learning curve from which he is not likely to remove himself of his own free will. If one of the elements of intelligence is ease in adjustment to a new situation, then naturally, other things being equal, the pupil of low intelligence will offer greater inertia to change from the plateau of his learning curve than will the pupil of high intelligence.

### SUMMARY OF CONCLUSIONS

When ability is measured in terms of the resulting product rather than the method used in getting that product, the practice method as herein defined—

1. Is considerably better than simply apprising pupils of the "best methods" as a means of teaching pupils how to review for an examination in general science.

2. Seems to increase in superiority with a decrease in the intelligence of the pupils with whom it is used.

3. Is not better and probably not so good for pupils of highest intelligence as apprising pupils of the "best methods"—the non-practice technique.

4. Does not show so great a superiority over the non-practice technique for reviewing for an examination as for solving originals in geometry.

# CHAPTER V

## READING FOR THE PURPOSE OF STUDYING

### WHAT IS CONSIDERED GOOD READING FOR THE PURPOSE OF STUDYING?

A great deal has been written concerning reading and its relationship to study and to school success. Considerable of what has been written has an experimental basis, but much more is purely opinion. Some of the opinion has been handed down from a time when there was no experimental psychology, and some of it represents an attempt to apply modern ideas of psychology and philosophy of education to principles of reading and study. Lyman [1] collected within 350 pages what is probably the best collection of suggestions of the non-experimental type—suggestions dealing with the relationship between reading and study. Gray [2] has brought together into one volume the experimental work that has been done in the field of reading. Most of the latter volume is concerned with the mechanics of reading as applied to the elementary school grades. Most of the contents of Lyman's compilation is written for the student who has acquired a marked proficiency in the mechanics of reading. Although the contents of these two collections cover two different types of reading ability and treat these in two different ways, there is enough evidence to show that reading, from the standpoint both of proficiency in the mechanics and of the "dynamogenic" aspect, is one of the most valuable tools for a high school pupil's success in the acquisition and organization of facts.

Monroe [3] secured the coöperation of 317 teachers to determine the types of learning in textbook study "in which reading is the central activity." Twelve types of learning were selected and their relative importance determined by teachers' opinion for

[1] Lyman, R. L., *The Mind at Work.* 1924.

[2] Gray, W. S., *Summary of Investigations in Reading.* University of Chicago, Monograph No. 28, 1925.

[3] Monroe, Walter S., *Types of Learning Required of Pupils in the Seventh and Eighth Grades and in High School.* University of Illinois Bulletin, Vol. 19, No. 15.

eleven subjects. The relative importance of each type of learning was determined by the percentage of teachers who considered it of importance in the eleven subjects selected. Although there was quite a divergence of opinion, depending upon the nature of the subject, about 50 per cent of the teachers claimed that "preparation of a summary which contains the central ideas of the assignment studied" and "preparation of an outline which gives the principal points and supporting details arranged to show the order of relative importance and relation to each other" are two types necessary for studying such subjects as geography, history, civics, and literature, and from 25 per cent to 35 per cent of the teachers claimed these two types are essential for chemistry, physiology, biology, and agriculture. (General science was not included among the eleven subjects mentioned.) Alderman [4] showed experimentally with pupils from Grades IV to VIII that a greater gain in comprehension of reading results from drill in organization than from drill in vocabulary or retention.

If these forms of study are important our high school pupils not only should be acquainted with the best way of outlining and writing a summary but also should be so familiar with their use that they have become an habitual tool. The question then arises, Which of the two experimental factors forming the basis for this study can be depended upon to give better results when applied to a study situation in which the accumulation of facts from the printed page comprises the main task?

We have no tests to measure such an ability other than general reading tests—tests of reading comprehension and reading speed. None of these tests, however, is concerned with measuring the degree in which a pupil can take a lengthy article—one built around two or more major points with several subdivisions—and extract from it the facts essential to the development of the article, with these facts properly organized to show their relation to each other and to the main theme of the article. This, however, is an essential operation in successful reading if the chief purpose of the reading is study.

Whatever method of testing such an ability is used, it (1) must provide a means for giving a written response to a mental operation; (2) must provide this means in as nearly a natural situation

[4] Alderman, Grover H., "Improving Comprehension Ability in Silent Reading." *Journal of Educational Research*, 13:11–21, Jan., 1926.

as possible; (3) must have a minimum "conditioning of the stimulus" which causes the response. The use of questions to determine what was done will tend to suggest what should have been done, and will be likely to result in an answer which is adjusted by the pupil to what he thinks is the intent of the teacher.

### SECURING INITIAL MEASURE OF ABILITY

The following course was pursued in securing the initial measure of ability in the study situation, reading for the purpose of studying. Two articles were selected consisting of material which (1) was likely to be of interest to tenth grade boys; (2) was built around two or more major divisions and several subdivisions; (3) was comparable in difficulty to articles or lessons which tenth grade pupils are called upon to read for the purpose of studying; (4) was likely to be new to them—at least of a type which they had not met in their school work heretofore.

The articles used, "Modern Glovemaking,"[5] and "The Tapeworm," are given in the Appendix, together with the outlines which were used as a basis for checking the pupil response.

Each pupil was given a copy of the following instructions:

> Outline this article in such a way *that you could use the outline, without the article, to study the contents* of the article.
>
> This means that you must include in the outline all essential facts in the article and place these in such a form that the outline will show their true relationships with each other and with the article.
>
> When you are satisfied that the outline has been completed, hand it in with the article.

Accompanying these instructions there was a short article, "Reading vs. Studying," which was intended to serve two purposes: (*a*) to give pupils a few suggestions for outlining and (*b*) to reveal to the examiner whether the pupil was familiar enough with outlining that the quality of the outlines finally handed in for the articles used as a measure of ability would not be affected materially by a lack of knowledge of the mechanics of outlining.

The examiner inspected each completed outline as it was handed to him and received it only if there was no evidence that the pupil was unfamiliar with the mechanics of outlining. Most pupils seemed familiar enough with outlining that their product was ac-

[5] The writer is indebted to Dr. Maxie N. Woodring, Assistant Professor of Education, Teachers College, Columbia University, for the outline of this article.

cepted the first time. A few, however, were questioned as to why they did what they had done, and if their answers or their written outlines did not satisfy the examiner they were required to make corrections or re-outline the entire article. No attempt was made, however, to accept or reject the outline on the basis of the selection of correct or incorrect major points. If the pupil had made a division of the article into parts and showed these parts in a coördinate and subordinate relationship, this fact was sufficient to determine its acceptance, provided the mechanics of outlining were properly complied with.

A copy of the above instructions accompanying the "Modern Glovemaking" article was given each pupil as he satisfactorily finished his trial outline. The "Tapeworm" article with the same set of directions was given to the class at its next meeting.

### *Method of Scoring Outlines*

It should be remembered that we are concerned in our scoring only with the extent to which the outline gives evidence of intelligent and efficient reading. The criteria which are selected as a basis for scoring must be those, therefore, which are criteria of intelligent and efficient reading and not criteria of a good outline, the outline serving simply as a means of detecting the extent to which the criteria for good reading have been violated. The mechanics of outlining are not therefore to be included as a scoring criterion. The following three criteria were finally isolated:

I. The reader must give evidence of having thought of the article as divisions of thought around which the details of the content can be grouped.
   A. This evidence must be found as main divisions of the article.
   B. This evidence must also be found as subdivisions of the main divisions.

II. The reader must have selected all the details essential to a complete development of the main thought of the article.

III. The reader must give evidence that he has thought of the divisions of (1) as logically coördinated and subordinated.
   A. This evidence must be found in the main divisions, IA.
   B. This evidence must also be found in the subdivisions, IB.

Only such subdivisions of the main divisions were considered in scoring for IB and IIIB of the criteria as would permit a grouping of detailed facts as a result of which grouping the facts themselves would show more clearly their relationship with each other. For example, in the "Modern Glovemaking" outline, "lambskins" and "sheepskins" were not given credit as subdivisions because their importance in the article is only that of detailed facts and in this respect they fall on a level with "salted," "soaked," etc. "Block-cutting" and "table-cutting," however, were given credit as subdivisons because the five details enumerated under "cutting" are more readily understood if grouped under the two subdivisions of which they are descriptive.

*Scoring Illustrated for "Glovemaking" Article*

*Criterion IA.*—The seven main divisions in the sample outline were recognized and a credit of 1.4 given for the inclusion of each division, making a total of 10 as a perfect score. Decision as to whether a statement in the pupil's outline was to be given credit as a main division depended upon the subjective opinion of the examiner.

*Criterion IB.*—The following eight subdivisions were recognized and credit given on the basis of 1.25 for each: "curing the skin," "dyeing," "thinning," "block-cutting," "table-cutting," "seams," "embroidery," and "thumbs." The same general principle that was used in *Criterion IA* for giving credit was applied here.

*Criterion II.*—In the right-hand margin of the sample outlines a series of numbers is found. These refer to the facts in the article which were given credit as essential facts. The "Glovemaking" article has 31 such recognized details, each of which is given a credit of .32. The only requirement for credit was a specific mention of the fact, clear enough that there seemed to be evidence of its recognition as a separate fact.

*Criterion IIIA.*—The same divisions were recognized as in IA. Two relationships are assumed—one to the main contents of the article of which it is a part, and another to the divisions or facts falling under it. A gross credit of 1 was given for each of these relationships, or a total of 14 possible gross credits for the whole article, which in terms of a scale of ten gives an actual credit value of .7 for each recognized gross credit.

*Criterion IIIB.*—The same general scheme was used here that was used for IIIA but as applied to subdivisions credited in IB.

Such a method of scoring is objective in that it gives credit on the basis of the number of facts or divisions given in the outline. It is subjective in that the determination of whether a particular fact or division is clearly enough stated to satisfy credit requirements is left to the judgment of the scorer.

In order to determine the reliability of such a method of scoring the 57 outlines of the "Modern Glovemaking" article submitted by the class and used as part of the initial measure of ability to read for the purpose of studying, were scored independently by two persons conversant with the purpose of the outline and the intended application of the criteria to the outline. A correlation of the scaling scores obtained by these two scorers for each of the criteria gave the following coefficients:

| | |
|---|---|
| Criterion IA | $.84 \pm .02$ |
| Criterion IB | $.71 \pm .04$ |
| Criterion II | $.85 \pm .02$ |
| Criterion IIIA | $.75 \pm .03$ |
| Criterion IIIB | $.69 \pm .05$ |

These coefficients are not high when viewed in the light of reliability of objective tests, but are higher than the reliability usually obtained for the highly subjective scaling methods used for scoring compositions and handwriting.

### *Combining Scores*

A weighting of 1 each was arbitrarily given to criteria IA and IB, and also to criteria IIIA and IIIB, so that scores for IA and IB were combined by simple addition. A similar combination of scores IIIA and IIIB was made. No attempt was made to combine the three resulting scores and get a single score for the outline. However, by scoring the outlines of the "Tapeworm" article in a similar manner, two scores resulted for each of these criteria, one score for each of the two articles outlined. A considerable difference in difficulty of these articles was shown by the scores obtained from the outline. Therefore, before the two scores for each criterion were combined, they were first expressed in comparable form by the use of the T scale or derived score technique explained in Chapter II. The average of each of these three pairs of derived scores was used as the initial relative score of ability included by the three

criteria. The means and standard deviations of these scores for each of the three groups are given in Table VI.

TABLE VI

INITIAL MEASURE OF ABILITY IN READING FOR THE PURPOSE OF STUDYING. AVERAGE OF DERIVED SCORES FOR "MODERN GLOVE-MAKING" AND "TAPEWORM" OUTLINES

| | PRACTICE GROUP (GROUP A) | | | NON-PRACTICE GROUP (GROUP B) | | | CONTROL GROUP (GROUP C) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Criterion | | | Criterion | | | Criterion | | |
| | I | II | III | I | II | III | I | II | III |
| Mean .... | 50.6 | 49.1 | 52.1 | 51.7 | 51.0 | 50.4 | 48.5 | 50.0 | 49.4 |
| S. D. ..... | 8.5 | 7.8 | 8.6 | 9.3 | 8.8 | 8.0 | 7.4 | 8.8 | 6.6 |
| P. E. $_{(mean)}$ | 1.35 | 1.24 | 1.37 | 1.40 | 1.33 | 1.22 | 1.15 | 1.36 | 1.02 |

PROCEDURE

McMurry and others emphasize the need of a hasty view of an article or lesson to get the general plan before a careful reading is made for details. Deich [6] found that of the 316 best pupils from 315 high schools in Iowa about half reported in answer to a direct and leading question, that they "read the assignment rapidly as a whole." Observation of the study habits of the average high school pupils, however, seems to indicate that very few pupils use the rapid survey of the whole as the preliminary step in reading for the purpose of studying.

No scientific analysis of this study situation being available, it was necessary to make an arbitrary selection of elements which when combined would create a procedure likely to be attended by greater success than the method of reading now usually used by high school pupils. Drawing upon the statements made by McMurry and others, the following was selected as the study method for our study situation—reading for the purpose of studying:

1. Skim the article to get the main divisions only.

2. Skim the article again to get the main subdivisions of each main division.

[6] Deich, Charles and Jones, Elmer. *A Study of Distinguished High School Pupils in Iowa.* U. S. Bureau of Education, Bulletin, 1923, No. 46.

3. Read carefully the contents of the article embracing each division properly coördinating and subordinating the facts contained therein under their proper subdivisions of the main divisions.

The "Tapeworm" article when outlined from such a reading procedure would appear as follows:

I. External appearance.
II. Internal structure.
III. Life history.
IV. Symptoms and treatment of disease.

---

IA. Size.
B. Head.
C. Body.

IIA. Alimentary system.
B. Excretory system.
C. Nervous system.
D. Reproductive system.

IIIA. In man—adult stage.
B. Without host—six-hooked embryo.
C. In pig—bladderworm stage.

IVA. Evidence.
B. Removal.

---

IA1. Width of narrow ribbon.
2. 20 to 40 ft. long.

B1. Pear-shaped with big end of pear front.
2. Double row of 28 curved and pointed hooks on front of head.
3. Four cup-shaped suckers around widest part of head.
4. Narrow (stem end) had body attached to it.

C1. Divisions known as segments or proglottides.
*a*. May have as many as 850.
*b*. Become larger the farther they are from the head.
2. Body flat with a dorsal and ventral side evident when seen under microscope.

IIA1. Absence shows that animal does not digest its own food.
B. (No subdivisions except a statement that it is present.)
C1. Brain consists of two poorly defined ganglia.
2. Two longitudinal nerves run full length of body.
3. Small nerves run to suckers.

D1. A complete system develops in each proglottide.
2. Most highly developed in last segment.
3. Often none are seen in the first 200 segments.

IIIA1. Fastened to intestine.
2. Taken into system by eating poorly cooked pork.
3. Taken into system as fully developed embryo in a cyst.
4. Cyst wall digested or dissolved off in stomach of man.

B1. Passed from intestine of man as single proglottide.
2. Eggs in proglottide develop into a young embryo.
3. Assumes form of a round body with six hooks.

C1. Eaten by pig and in this way gets into digestive tract.
2. Bores its way through digestive tract into muscles or flesh.
3. Forms a cyst and develops to appearance of head of parent.

IVA1. Unusual appetite of human being having tapeworm without getting any apparent nourishment from food eaten.

B1. Period of fasting followed by taking a good dose of castor oil.
2. Head of tapeworm must be removed to be certain of being rid of disease.

---

It will be noticed that an outline of this kind is not so easily read by the novice as one in which all the contents of the second main division are shown. It should be borne in mind that we are not concerned primarily with outlining for the sake of the outline, but we are concerned rather with getting a pupil to pass (mentally) through those steps which comprise the elements of our study situation. However, in order to be assured that he passes (mentally) through these steps there must be a motor response to his mental process. This motor response takes the form of the outline shown here.

*Procedure with Group B.*—An article, "Reading for the Purpose of Studying," [7] composed by the writer, was placed in the hands of each pupil for study. The facts contained therein were used as a basis for class discussion, showing how they apply to various types of study material—general science, history of American literature, and other historical and descriptive material. The "Tapeworm" article was used to show how this could have been outlined by the reading method just explained. The principle set forth in this article was also applied to getting the main subdivisions. The "Tapeworm" article, two lessons in general science, and articles entitled "History of the Match" and "The Moon" were outlined orally in class in order to show the procedure to be used in reading an article for the purpose of studying. Reading assignments were made from Lyman, Sandwick, and Kitson, such articles being selected as applied directly or indirectly to skimming, outlining, or reading necessary for studying. The chapter by Kitson on "Concentration of Attention" was assigned because of the pertinence of its contents to the fourth of the five

[7] See Appendix.

points mentioned in the article, "Reading for the Purpose of Studying," given in the Appendix, the focal point being the big units of thought discussed in the article and the marginal points being the details mentioned in the article being skimmed, the latter to be submerged and the former to be held in prominence to the exclusion of the details or suggested ideas when skimming. Other assigned articles bore a similar relationship to the skill which the class was aiming to develop.

*Procedure with Group A.*—The article "Reading for the Purpose of Studying" used with Group B was also given to Group A to be studied. This was the only material required to be studied by this group. It was found, however, that its application to the "Tapeworm" article had to be discussed in class before the group as a whole could proceed intelligently with its use. For each article given the class to be outlined the following directions were used:

Taking the article given you, skim it quickly in order to select the number of main points which the article contains. (Remember that hints may be found in the introductory sentence or paragraph or a summary in the last paragraph; remember also that skimming implies reading by paragraphs or other large units.) The correct or most likely number of main points in the article is mentioned on the board. Express each of these main points in a single word or phrase or a short sentence. Sometimes it is well to put the main points into the form of a question. Always aim to select the shortest and most descriptive or explanatory wording you can think of. This need not, and often should not, be the exact wording used in the article which you are reading, but it should be so worded that its relationship to the title of the article is evident.

Place your wording of each of these main divisions after the appropriate Roman number indicating the order in which it appears in the article.

If a checking sheet is provided check your results and give yourself a percentage score. When checking, the exact wording on the checking sheet need not be used but the same thought must be indicated.

The above directions apply only to skimming in order to select main divisions of the article. After the group had practice in skimming for main points, the following directions were substituted:

1. Skim for main points, placing them after I, II, etc. Get checking sheet and check for correct ideas contained in the main points, and give yourself a percentage score.
2. Using main points mentioned on checking sheet (not those on your own paper) skim each section of the article to select the main subdivisions for

each of these main divisions and write them on your paper after IA, IB, IIA, etc. Check and score as in (1).

3. Using checking sheet for (2) determine all the subdivisions of the main divisions, after a careful reading of that section of the article, and place them after IA1, IA2, IIB1*a*, etc. Continue this outlining until all important separate facts in the article have been included—placed in connection with or under the heading to which they are related.

*Remember* that outlining is not simply an enumeration of facts, but their enumeration so placed that their relationships to the article as a whole and its several divisions are clearly shown.

A great variety of written responses was given for any one article or lesson. In a few cases it was necessary to give considerable individual attention to get a pupil to select main divisions of thought instead of simply enumerating facts. Another difficulty existed when lessons, particularly from the general science text, were used as practice material. Pupils apparently had formed the habit of selecting thoughts in paragraphs or small sections without regard to the relation of each to the whole. Consequently, in skimming they were likely to have as many main divisions as there were separate sections in the lesson. Since the textbook used was poorly organized, the main points enumerated by the pupil were inclined to take the form of so many facts which had very little relation to each other or to the main thought of the lesson.

The time that could be given to this practice material was not sufficient to break this habit and substitute the desired habit for some of the pupils. The articles "History of the Match," "The Moon," "The Tapeworm," etc., were much more readily skimmed and outlined as directed, partly perhaps, because they were not broken into paragraphs with heavy-type headings which misled pupils as to their import.

One can readily see that checking and scoring material of this nature by a pupil is not easy, nor are the percentage scores accurate; but this is not essential, for the chief purpose of the checking and scoring is to get the pupil to note the differences between his results and those which are considered correct, and also to give him at least a rough measure of his own improvement as determined by the percentage scores obtained for the successive articles outlined.

The total time devoted to the instruction and practice mentioned in this chapter comprised about two months.

### MEASURE OF IMPROVEMENT

Three articles were outlined as a measure of the final ability to read for the purpose of studying—"Matter, What Is It?," "Mosquitoes," and "Modern Glovemaking." [8] The "Glovemaking" article was purposely not discussed or referred to in any of the groups between the initial and final testing period so that it could be used as a measure of final ability and the absolute gain in a particular task determined. As a second measure of gain in ability, the three scores obtained for each of the three criteria—one score for each of the articles above mentioned—were combined in the same manner as the two scores of initial ability were combined, viz., by expressing each raw score as a derived score and averaging the derived scores. Each of these two measures of gain in ability will be considered separately.

TABLE VII

INITIAL AND FINAL SCORES FOR "GLOVEMAKING" ARTICLE

| | Initial Scores | | | Final Scores | | |
|---|---|---|---|---|---|---|
| | Criterion | | | Criterion | | |
| | I | II | III | I | II | III |
| **PRACTICE GROUP (GROUP A)** | | | | | | |
| Mean | 9.1 | 5.2 | 6.7 | 11.8 | 5.9 | 9.8 |
| S. D. | 1.97 | 1.40 | 2.61 | 1.46 | 1.63 | 1.72 |
| P. E. $_{(mean)}$ | .31 | .22 | .41 | .23 | .26 | .26 |
| **NON-PRACTICE GROUP (GROUP B)** | | | | | | |
| Mean | 8.7 | 5.4 | 6.0 | 11.4 | 5.4 | 8.0 |
| S. D. | 2.68 | 1.81 | 3.00 | 2.00 | 2.00 | 2.71 |
| P. E. $_{(mean)}$ | .40 | .27 | .45 | .30 | .30 | .41 |
| **CONTROL GROUP (GROUP C)** | | | | | | |
| Mean | 8.1 | 5.3 | 6.3 | 9.2 | 5.7 | 7.1 |
| S. D. | 2.36 | 1.64 | 2.3 | 3.29 | 1.38 | 3.32 |
| P. E. $_{(mean)}$ | .36 | .25 | .36 | .51 | .21 | .51 |

[8] For each of these articles, see Appendix.

RESULTS

*Improvement in Outlining the "Glovemaking" Article.*—Table VII gives the averages of the initial and of the final raw scores for the "Glovemaking" article, thereby making possible a comparison of group gains in the ability to perform a given task before and after the period of experimentation.

A comparison of the initial and final scores of this table reveals the following increases in group mean and differences in these increases as well as the ratio of significance of these differences (significance again being determined by a ratio of the actual difference to the P.E. of the difference, a ratio of 4 or more being usually classed as highly significant and a ratio of 3 indicating that the odds of occurring are 22 to 1).

| | Increase in Means | | | Significance of Increase | | |
|---|---|---|---|---|---|---|
| | Criterion | | | Criterion | | |
| | I | II | III | I | II | III |
| Group A | 2.7 | .7 | 3.1 | 6.9 | 2.1 | 6.3 |
| Group B | 2.7 | .0 | 2.0 | 5.4 | 0.0 | 3.3 |
| Group C | 1.1 | .4 | .8 | 1.7 | 1.2 | 1.3 |

| | Differences in Increases | | | Significance of Differences | | |
|---|---|---|---|---|---|---|
| | Criterion | | | Criterion | | |
| | I | II | III | I | II | III |
| Comparing A with B | 0.0 | .7 | 1.1 | 0.0 | 1.3 | 1.5 |
| Comparing A with C | 1.6 | .3 | 2.3 | 3.0 | .8 | 3.5 |
| Comparing B with C | 1.6 | − .4 | 1.2 | 2.8 | .6 | 1.3 |

From these data we may draw the following conclusions:

1. The improvement of the practice group was marked and highly significant for criteria I and III, but small and only slightly significant for criterion II.

2. The improvement of the non-practice group was also marked

## TABLE VIII

DERIVED SCORES RESULTING FROM OUTLINES OF ARTICLES, "MATTER, WHAT IS IT?," "MOSQUITOES," AND "MODERN GLOVEMAKING." FINAL MEASURE OF ABILITY.

| | "MATTER" | | | "MOSQUITOES" | | | "GLOVEMAKING" | | | AVERAGE | | | RELATIVE GAINS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Criterion | | | Criterion | | | Criterion | | | Criterion | | | Criterion | | |
| | I | II | III | I | II | III | I | II | III | I | II | III | I | II | III |
| PRACTICE GROUP (GROUP A) | | | | | | | | | | | | | | | |
| Mean | 56.0 | 49.0 | 57.5 | 56.5 | 51.3 | 56.8 | 53.5 | 51.2 | 55.5 | 55.4 | 50.4 | 56.5 | 4.8 | 1.9 | 4.1 |
| S. D. | 8.6 | 8.6 | 9.0 | 6.7 | 5.5 | 7.1 | 7.3 | 7.6 | 9.9 | 6.9 | 6.1 | 5.6 | ---- | ---- | ---- |
| P. E. $_{(mean)}$ | 1.31 | 1.43 | 1.07 | .88 | 1.13 | 1.16 | 1.2 | 1.57 | 1.10 | .61 | .97 | .89 | ---- | ---- | ---- |
| NON-PRACTICE GROUP (GROUP B) | | | | | | | | | | | | | | | |
| Mean | 51.4 | 53.4 | 51.1 | 50.0 | 50.0 | 49.7 | 51.8 | 48.4 | 48.7 | 51.0 | 50.6 | 49.9 | − .4 | − .4 | − .6 |
| S. D. | 9.4 | 9.6 | 9.5 | 10.9 | 12.0 | 10.3 | 9.3 | 11.2 | 9.0 | 8.0 | 9.1 | 8.1 | ---- | ---- | ---- |
| P. E. $_{(mean)}$ | 1.42 | 1.44 | 1.43 | 1.64 | 1.81 | 1.55 | 1.41 | 1.69 | 1.35 | 1.21 | 1.38 | 1.22 | ---- | ---- | ---- |
| CONTROL GROUP (GROUP C) | | | | | | | | | | | | | | | |
| Mean | 42.6 | 47.5 | 42.4 | 44.0 | 47.9 | 44.0 | 44.1 | 50.4 | 46.1 | 43.5 | 48.8 | 44.3 | − 3.0 | − 1.2 | − 5.2 |
| S. D. | 7.2 | 10.9 | 5.2 | 7.8 | 8.8 | 7.3 | 9.6 | 8.1 | 10.6 | 7.0 | 7.7 | 6.1 | ---- | ---- | ---- |
| P. E. $_{(mean)}$ | 1.11 | 1.69 | .81 | 1.21 | 1.36 | 1.1 | 1.49 | 1.25 | 1.6 | 1.08 | 1.19 | .94 | ---- | ---- | ---- |

and highly significant for criterion I, fair and reasonably significant for criterion III, and zero for criterion II.

3. The improvement of the control group was small and insignificant for all three criteria.

4. The effect of the practice technique was not superior to the effect of the non-practice technique for criterion I and only slightly better but not highly significant for criteria II and III.

*General Improvement in Outlining as Measured by All Tests.*—Reference to the article entitled "Matter, What Is It?" reveals the fact that it is more difficult to read than any of the other articles, and therefore more difficult to outline, because it contains more facts which are not directly relevant to the main theme of the article and yet tend to detract attention from the central thought. The "Mosquitoes" article may be considered to fall somewhere between the "Glovemaking" and "Matter" articles in this type of difficulty. Such articles would therefore tend to serve as a greater challenge to the ability of the reader and would be more likely to measure any difference in increase in ability between the three groups of pupils.

Table VIII gives group averages of the derived scores for each of the three criteria for the three articles used as a final measure of ability, as well as the average scores for each criterion when the scores for the three articles are combined. The last column shows the average relative gain or loss for each group in each of the three criteria, and is obtained by subtracting the pupils' initial derived score from the final derived score and taking the mean of these differences for each group of pupils. The differences are merely relative and do not indicate that a negative difference means an actual loss in ability, but merely a loss in position in a distribution scale containing the pupils of the three groups.

*Comparison of Data.*—A comparison of the relative gains of one group with those of the other groups gives scores which indicate actual differences between groups, the differences being expressed in derived scores. The significance of these differences can be determined, as before, by dividing the actual difference by the P. E. of the difference. Such a treatment of the data will give the scores and significant ratios shown on page 62.

From these data, the following conclusions may be drawn:

1. Pupils who were subjected to the practice technique during the period of the experimentation showed a very marked improve-

| | Differences in Gains | | | Significance of Differences | | |
|---|---|---|---|---|---|---|
| | Criterion | | | Criterion | | |
| | I | II | III | I | II | III |
| Comparing A with B ..... | 5.2 | 2.3 | 4.7 | 2.6 | .4 | 2.1 |
| Comparing A with C ..... | 7.8 | 3.1 | 9.3 | 3.8 | 1.5 | 4.4 |
| Comparing B with C ..... | 2.6 | .8 | 4.6 | 1.3 | .3 | 2.1 |

ment in the ability to read for the purpose of studying, as this ability was measured by the outlining, and as this ability is concerned with criteria I and III.

2. Pupils who were subjected to the non-practice technique showed only a slight gain in these two criteria.

3. Neither technique had any marked or significant effect on the ability included in criterion II.

*Effect on Different Intelligence Levels.*—If we determine the relative gains or losses for (*a*) pupils in the lowest quarter in intelligence, (*b*) pupils of the highest quarter, (*c*) those of the lower half, and (*d*) those of the upper half, and then determine the differences in the gains of pupils of Groups A, B, and C for the four intelligence levels the data given below will result:

| | Lowest 25 Per Cent | | | Highest 25 Per Cent | | | Lower Half | | | Upper Half | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Criterion | | | Criterion | | | Criterion | | | Criterion | | |
| | I | II | III | I | II | III | I | II | III | I | II | III |
| Comparing A with B | 6.2 | 7.3 | 10.4 | 3.2 | −.6 | 2.8 | 8.8 | 4.3 | 8.3 | 1.4 | .3 | .8 |
| Comparing A with C | 11.1 | 13.8 | 14.8 | 13.6 | −.5 | 7.8 | 9.1 | 6.4 | 13.2 | 6.6 | −.2 | 6.2 |
| Comparing B with C | 4.9 | 6.5 | 6.2 | 10.4 | .1 | 5.0 | .3 | 2.1 | 3.9 | 5.2 | −.5 | 5.4 |

It should be remembered that these are actual differences resulting from derived scores. A gain of 6.2 therefore means a gain nearly one half as great as a gain of 11.1, but it does not mean a gain of 6.2 units on our original scale of ten used for scoring pur-

poses. Percentages of gain cannot be determined because the numbers from which these gains are derived are only relative. For example, the relative gain of the lowest 25 per cent of Group A in criterion I is found to be 8.5, and of Group C—2.6, making an actual difference in gain of 11.1; but since our beginning point in this relative scale is not zero it is impossible to determine the per cent of gain of Group A over Group C.

A comparison of the resulting differences in gains reveals the following facts:

1. The actual gain of Group A over Group C is greater than the gain of Group B over Group C for all levels of intelligence for criteria I and III, but greater for criterion II only with pupils of below average intelligence.

2. The superiority of Group A over Group C is at least twice as great as the superiority of Group B over Group C in all cases in which pupils of below average intelligence are concerned.

3. This difference, however, becomes negligible when pupils of above average intelligence are concerned.

4. The effect in criterion II of the experimental factors on pupils of above average intelligence seems negligible, with a tendency toward the negative.

## SUMMARY OF CONCLUSIONS

The conclusions that can be drawn from a comparison of increase in ability in outlining the "Glovemaking" article with the increase in ability as measured by all the articles used—two for initial ability and three for final ability—differ in one respect; the former shows no significant superiority of Group A over Group B, whereas the latter does show a slightly significant superiority for criteria I and III. In other respects the two sets of conclusions are similar.

The general conclusions which can be drawn from the effect of the experimental factors on the study situation, reading for the purpose of studying, are the following: If the improvement in ability to outline, when an outline is evaluated by the three criteria selected herein, is an index of improvement in reading habits, then—

1. The reading habits of high school pupils can be improved if pupils are specifically and definitely apprised of what they should do.

2. The reading habits can be improved to a somewhat greater

degree if instead of simply apprising pupils of what they should do, they are provided with systematic practice in the use of the elements comprising the particular reading habit to be developed.

3. The ability of pupils in selecting essential facts is not improved by either method of instruction, but rather their ability to read with logical organization in mind.

4. The practice technique is generally better for pupils of below average intelligence.

5. The non-practice technique is probably equal to the practice technique for pupils of above average intelligence.

# CHAPTER VI

## GENERAL CONCLUSIONS

### DEGREE OF EQUALITY MAINTAINED

Three groups of tenth grade high school boys were used, each group equal (as nearly as equality could be reached) to the other two groups in those factors which are usually regarded as essential elements for school success. Equality was sought also in the type of classroom activities in which the members of each group were engaged in their daily school routine. In so far as the experiment could be controlled the three groups differed in only one respect; namely, Group C prepared its daily classroom assignments without any suggestions or helps other than those which were incidental to the administrative and instructional practice of the school, such as study halls, assignment, system of awarding honors, after-school help upon the request of pupils, and the like. Group B had the same advantages as Group C with one exception; namely, two study periods a week, during which the pupils of Group C were permitted to study as they pleased, were devoted to a course in how to study, the aim of which was to give pupils of Group B a knowledge of what constitutes the best methods of study, with emphasis on three types of study situations, in the hope that they would translate this knowledge into practice and thereby improve their study habits.

Group A differed from Group C in but one respect; namely, two study periods a week were devoted to giving a systematic practice in the use of the three types of study situations which had received emphasis with Group B. The contact time between pupils of Groups A and B and the writer was therefore uniform, but the quality of that contact was different. The quality, however, was similar in that both groups placed equal emphasis (in so far as equality could be maintained with a difference in method) on three types of study situations, all of which were engaged in by all tenth grade pupils in this school. These three types of study situations were: solution of originals in geometry, review-

ing for an examination in general science and geometry, and reading for the purpose of study.

Groups A and B differed in one other respect. When the contact between the writer and these pupils began in the Fall of 1925, the writer had outlined a fairly definite procedure for Group B. He also had in mind certain activities in which practice was to be provided for Group A and had outlined a tentative procedure. It was found, however, to be impractical in the setting in which it was intended to be used and had to be discarded. A period of two months therefore elapsed before the writer found the study situations herein isolated and was prepared with sufficient practice material to insure its successful use. During this time the pupils of Group A were used as an observation and trial-and-error experimental group. During the same two-month period Group B continued its work as originally planned, the three study situations on which emphasis was placed being inserted into the B plan when practice material was begun to be used with Group A.

### EVALUATION OF RESULTS

Three questions present themselves in our attempt to evaluate the year's work:

1. To what extent did the experimental factors affect the achievement of these pupils when achievement is measured in its usual school form—teachers' marks?
2. To what extent did the experimental factors result in proficiency in the specific study situations which had been isolated?
3. What evidence is there of an actual formation of better study habits?

*Effect on School Marks.*—Table IX gives data showing the average achievement of the pupils in Groups A, B, and C for the school year 1925–26. The teachers' marks for the year were treated in the manner explained in Chapter II, and the data presented in these tables are the means of the derived scores for the teachers' marks. The intelligence scores are the same as those used for original equating of the groups. The differences given in the last column indicate the extent to which the pupils of each group changed their relative position of achievement between June, 1925, and June, 1926. This number is obtained

by subtracting the pupil's studious index for 1925 from his studious index for 1926 and averaging these differences for each group.

TABLE IX

DERIVED SCORES FOR SCHOOL MARKS 1925–26 AND RELATIVE IMPROVEMENT OVER 1924–25

| GROUP | ENGLISH | FRENCH | LATIN | MATHEMATICS | SCIENCE | ACHIEVEMENT AVERAGE | STUDIOUS INDEX | IMPROVEMENT OVER PRECEDING YEAR |
|---|---|---|---|---|---|---|---|---|
| PRACTICE GROUP (GROUP A) | | | | | | | | |
| Mean | 49.6 | 52.2 | 49.7 | 53.7 | 46.9 | 50.9 | .21 | − .68 |
| S. D. | ---- | ---- | ---- | 7.2 | 11.0 | 5.2 | ---- | 3.87 |
| P. E. (mean) | ---- | ---- | ---- | 1.2 | 1.7 | .8 | ---- | .61 |
| NON-PRACTICE GROUP (GROUP B) | | | | | | | | |
| Mean | 48.4 | 49.0 | 50.0 | 49.1 | 45.9 | 48.2 | −1.5 | −2.95 |
| S. D. | ---- | ---- | ---- | 9.4 | 11.6 | 7.4 | ---- | 6.00 |
| P. E. (mean) | ---- | ---- | ---- | 1.42 | 1.8 | 1.1 | ---- | .91 |
| CONTROL GROUP (GROUP C) | | | | | | | | |
| Mean | 51.4 | 48.8 | 50.4 | 49.4 | 39.6 | 50.1 | −1.9 | −3.35 |
| S. D. | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 5.50 |
| P. E. (mean) | ---- | ---- | ---- | ---- | ---- | ---- | ---- | .83 |

1. What has been the effect of our experimental factors on the pupils' total year's work as measured by their studious indices?

2. What has been the effect of our experimental factors on the pupils' year's work in those subjects in which the three study situations used in this study were most likely to be used?

## EFFECT ON PUPILS' ACHIEVEMENT AS MEASURED BY STUDIOUS INDEX

A comparison of the group averages of the "relative improvement" indices reveals a superiority of Group A over Group B of 2.27, of Group A over Group C of 2.67, and of Group B over Group C of .40, with significant ratios of 2.1, 2.6, and .32 respectively. Although the significance is not high, it is high enough for the first two differences to indicate a probable superiority.

If we resort to the same treatment of our data as was used in previous chapters—comparing differences for the four intelligence levels, (*a*) lowest 25 per cent, (*b*) highest 25 per cent, (*c*) lower half, and (*d*) upper half—the following differences are found:

| | Lowest 25 Per Cent | Highest 25 Per Cent | Lower Half | Upper Half |
|---|---|---|---|---|
| Comparing A with B ..... | 3.3 | −2.3 | 3.7 | .8 |
| Comparing A with C ..... | − .8 | 4.1 | 1.6 | 3.7 |
| Comparing B with C ..... | −4.1 | 6.4 | −2.1 | 1.6 |

Because of the great variability in these groups these differences are not highly trustworthy.

From these two methods of comparison we may conclude that:

1. The use of the practice technique had a small and fairly significant effect on the year's work of Group A.

2. The non-practice technique had no significant effect on the year's work of Group B.

3. Such superiority as the practice technique had over the non-practice technique is confined almost wholly to pupils of below average intelligence.

4. The only marked effect that the non-practice technique seemed to have is confined to pupils in the highest quarter of intelligence.

### Effect on Year's Achievement in Geometry and General Science

In attempting to evaluate the effect of our experimental factors on the year's achievement in geometry and science we are faced with the question of determining the initial abilities of the three groups in these two subjects. Two possibilities present themselves: (1) assuming that the original equating brought about an equality of ability in these subjects; (2) assuming that the relative abilities of these two groups is indicated by the group averages for the year 1924–25 in the most nearly allied subjects. During the previous year all of these pupils had a course in health hygiene under the title of science, which in content and general method of attack is closely allied to general science, and a course in algebra, which

can be said to require an ability very closely allied to that of geometry.

Probably neither of these possibilities gives us an absolutely true measure of initial ability, but since each is closely related to the true measure, the use of both should give us facts from which fairly valid conclusions can be drawn. Data for both assumptions are given below.

| | Assuming Initial Equation Resulted in Equal Group Abilities | | Assuming Achievement Scores for 1924–25 Indicate Relative Group Abilities | |
|---|---|---|---|---|
| Actual Difference | When Total Group Means are Compared | | | |
| | Geometry | Science | Geometry | Science |
| Comparing A with B | 4.6 | 1.0 | 4.0 | − 1.3 |
| Comparing A with C | 4.3 | 7.3 | 3.0 | 8.5 |
| Comparing B with C | − .3 | 6.3 | − 1.0 | 9.8 |
| Significance Ratio | | | | |
| Comparing A with B | 2.5 | .4 | 2.5 | .4 |
| Comparing A with C | 2.5 | 2.7 | 2.2 | 2.5 |
| Comparing B with C | .2 | 2.4 | .4 | 3.0 |

| Actual Difference | When Pupils of Different Intelligence Levels are Compared | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Geometry | (a) | (b) | (c) | (d) | (a) | (b) | (c) | (d) |
| Comparing A with B | 8.7 | − 7.2 | 8.1 | 1.3 | 6.2 | − 5.0 | 5.8 | 1.9 |
| Comparing A with C | 6.7 | − .6 | 5.0 | 3.8 | 3.2 | − 2.7 | 4.7 | .8 |
| Comparing B with C | − 2.0 | 7.6 | − 3.1 | 2.5 | − 3.0 | 2.3 | − 1.1 | − 1.1 |
| Science | | | | | | | | |
| Comparing A with B | 8.8 | − 6.2 | 6.6 | − 4.9 | 4.1 | − 13.8 | 5.4 | − 6.2 |
| Comparing A with C | 7.8 | − 8.6 | 12.2 | 2.1 | 5.8 | 3.2 | 11.8 | 7.1 |
| Comparing B with C | − 1.0 | 7.6 | 5.6 | 7.0 | 1.7 | 17.0 | 6.4 | 13.3 |

From these data we may draw the following conclusions:

1. The practice technique had a marked and fairly significant effect on the group as a whole in science, and a smaller but fairly significant effect in geometry.

2. The non-practice technique had a marked and fairly significant effect on the group as a whole in science but not in geometry.

3. The practice technique is superior to that of non-practice for the group as a whole in geometry but not for science.

4. For geometry, the effect of the practice technique is confined almost wholly to pupils of average and below average intelligence; if it has any effect on pupils in the highest quarter of intelligence, the effect is negative.

5. For geometry, the effect of the non-practice technique seems to be confined almost wholly to pupils of the highest quarter in intelligence, and is probably negative for pupils of below average intelligence.

6. For geometry, the superiority of the practice technique over that of non-practice is decided for pupils of below average intelligence, but the reverse is true to an equally marked degree for pupils in the highest quarter in intelligence.

7. For science, the practice technique is superior to that of non-practice for pupils of below average intelligence, and the reverse is true for pupils of above average intelligence.

Data from both of our assumptions tend to point to the above conclusions and generally agree except for the effects in science of the two experimental factors on pupils of different intelligence levels. In this case agreement does not extend beyond conclusion 7.

### EFFECT ON ISOLATED STUDY SITUATIONS

The three study situations used represent types. One is taken from the field of mathematics, is concerned with inductive and deductive reasoning, and was met for the first time in this form by these pupils; consequently, the pupil's individual achievement generally was no doubt found on a point of his learning curve nearer zero than its plateau, or at least not on its plateau. The habits of study, therefore, had not been permanently fixed. The actual need of proficiency in this study situation was also quite apparent to pupils because of their day by day contacts with its use in their geometry classes. Motivation, therefore, was not difficult.

The second study situation, reviewing for an examination, is one which supposedly had been used by the pupils for several years, not with geometry and general science, but with other subjects comparable in type. It can be expected, therefore, that in so far as they engaged in any review for examinations they had reached the point on their learning curve at which greater efficiency resulting solely from their own unguided efforts was not likely.

It is equally to be expected that those who were satisfied with taking examinations without reviewing would not solely from their own initiative now adopt any other methods. In this respect they also had reached the plateau of their learning curve. This study situation, however, was one in which all pupils were actually engaged in the form in which they were accustomed to engage in it, and could therefore be properly motivated. In this respect it resembles the first study situation.

The third study situation is unique in that it not only finds a pupil on the plateau of his learning curve, but it does not, in the thought of the pupil, involve an ability which requires remedial treatment. He knows how to read for the purpose of study; he has done this for several years. He has been getting passing marks, and, in fact, he has been getting better marks as a rule in history, hygiene, geography, and other similar subjects than in Latin or mathematics. At least, this represents his point of view. This fact makes motivation very difficult, and any method of improving this study habit which has to depend for its success on a consciousness of a need of improvement is inherently at a disadvantage.

The technique used in these three study situations and their method of application differ in certain outstanding respects:

1. The study situation, solving originals in geometry, was analyzed into finer elements than was the case with the other two, and, with the exception of the last, the steps in the practice material are so short and definite that their application leaves a minimum to the initiative of the pupil. The last step differs in this respect, but even in this case the correct use of the previous steps provides material which makes the last step easier of application.

These steps also require a minimum of motor response to indicate the mental operation of the pupil, a response which ordinarily is put into writing in some manner in the usual method of solving originals. This creates a condition, which, to the pupil, does not seem so artificial as the technique used for reading for the purpose of studying.

As a whole, the writer believes that the technique for this study situation, in the form in which it is used herein, can be adapted to be used in geometry classes in charge of the average teacher.

2. The study situation, reviewing for an examination, as used herein was not provided with a technique that can be said to be

definite, partly because the nature of this study situation does not permit of so much definiteness as is the case with the previous study situation, and partly because not enough opportunity was afforded to correct and adapt the technique to the difficulties discovered in its use. There was but one examination for which the technique was used; there were many originals in geometry in which it was used before the final technique was evolved. The technique used in reviewing for an examination required a great deal more of the initiative of the pupil for success. Furthermore, the motor response required did not insure so good a checking on the thinking of the pupil as was desired. As a whole, therefore, the writer believes that the technique for this study situation in the form in which it is given herein leaves to the teacher as well as the pupil so much need for adaptation that success from its use by the average teacher is questionable.

3. What was said of the second study situation applies similarly to the third. Because of the fact that a particular response by the pupil could not always be said to be absolutely right or wrong, it was difficult to create checking sheets that were clear enough to be understood by the pupil and at the same time adjustable enough to fit into the various responses which pupils might have made, all of which probably differed in wording. With this difficulty, having the pupil correct his own response raises a problem which can be handled only by the teacher who has a thorough control of the class activity, and this with a heterogeneous group of pupils is not easy. This study situation probably is more definite in its technique than the second, but it does not approach the definiteness contained in the first.

A subjective evaluation of these study situations is given above by the one who has worked with them, in order that the summary of the conclusions given below can be better evaluated by the reader in the light of facts which the data themselves do not reveal.

### SUMMARY OF CONCLUSIONS

The data of Chapters III, IV, and V seem to indicate (if we exclude reviewing for an examination in geometry, which showed nothing) that: (1) systematic practice in the use of the elements of a study situation is a great deal more effective for the high school pupils as a whole than is knowledge of what these study elements are: (2) the effectiveness of the practice method over the non-

practice method increases with a decrease in the intelligence of the pupils and is therefore far superior for pupils in the lowest quarter or even lower half in intelligence; (3) a knowledge of what constitutes the best method of study is at least equal and perhaps superior to practice only, for the pupils of highest intelligence—those of the highest quarter; (4) the use of the practice method of teaching pupils how to study increases the homogeneity of groups or classes of high school pupils if the measure of ability consists of our usual tests of acquisition of specific facts or abilities rather than a measure of habits or attitudes developed; (5) the more the technique which is used provides a definite and specific task for the pupil, the greater is the value of the practice method over the non-practice method for pupils of below average intelligence; and the more it leaves to the initiative of the pupil, the greater is its value to the pupils of above average intelligence.

*Effect of Thoroughness of Knowledge of Facts on the Above Results.*—Since Group B showed generally a smaller gain as a result of the use of its experimental factor in each of the three isolated study situations than was shown by the practice group (Group A), the question naturally arises as to how well these pupils knew what was to be done in each study situation. The answer to such a question will be of value only in a comparative way. How much better did they know what to do than those of the other groups knew what to do? In attempting to answer this question the writer was faced with the difficulty of getting questions (*a*) which could be understood by those who had received no class instruction in such knowledge; (*b*) which were so definitely connected with study practice that they could be said to represent a concrete situation; (*c*) the answers to which could be scored objectively; (*d*) which adequately covered the field of activity in which Groups B and A were engaged during the year; (*e*) the desired answer to which could reasonably well be defended, in the light of modern psychology and pedagogy, as resulting in greater achievement if carried into practice; (*f*) the answer to which was not so self-evident that it presented no problem to the pupil.

One hundred sixteen statements[1] were finally devised, half of which were true and half false. These were required to be answered like the ordinary true-false test by the use of plus and minus signs. Twenty-eight of these questions were concerned

[1] See Appendix.

primarily with reading for the purpose of studying as interpreted in Chapter V; 24 with reviewing for an examination in science; 13 with reviewing for an examination in geometry; 22 with the solution of originals in geometry; the remaining 29 cannot be properly assigned to any of the specific study situations isolated herein.

Table X shows the average scores for each of the three Groups in each type of question. The score in each case represents the

TABLE X

SCORES IN TRUE-FALSE FACT-KNOWLEDGE TEST

| PRACTICE GROUP (GROUP A) | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Mean | 57.5 | 16.0 | 15.9 | 5.1 | 14.5 |
| S. D. | 12.3 | 3.0 | 4.1 | 3.2 | 5.4 |
| P. E. $_{(mean)}$ | 2.0 | .5 | .7 | .5 | .9 |
| NON-PRACTICE GROUP (GROUP B) | | | | | |
| Mean | 81.0 | 15.5 | 17.8 | 8.4 | 19.8 |
| S. D. | 13.8 | 3.4 | 3.3 | 2.8 | 4.9 |
| P. E. $_{(mean)}$ | 2.1 | .5 | .5 | .4 | .7 |
| CONTROL GROUP (GROUP C) | | | | | |
| Mean | 36.4 | 9.8 | 10.8 | 3.5 | 6.0 |
| S. D. | 13.0 | 4.9 | 3.7 | 3.3 | 4.4 |
| P. E. $_{(mean)}$ | 2.0 | .8 | .6 | .5 | .7 |

(1)—Total score.
(2)—Score in questions dealing with solution of originals in geometry.
(3)—Score in questions dealing with reviewing for an examination in science.
(4)—Score in questions dealing with reviewing for an examination in geometry.
(5)—Score in questions dealing with reading for the purpose of studying.

total number of questions wrong subtracted from those which were right. Some of the correct answers no doubt are the result of correct guesses, but we have no reason to believe that in so far as a chance guess resulted in a correct answer one group of pupils was better than another group of pupils.

When these data are treated in the same manner as our previous data the results which are given in Table XI are revealed.

It must be remembered that a different highest possible score exists for each set of questions and that the above scores are com-

parable only as absolute scores as they apply to the same set of questions (total score, or originals in geometry, etc.), but are comparable in a relative manner with scores for a different set of questions. For example, Group A pupils of lowest intelligence show a superiority of 1.2 over Group C pupils of lowest intelligence in the questions dealing with science review. This indicates a superiority only about one-fifth as great as that shown by Group B pupils over Group C for the same intelligence level and set of questions (the latter superiority being 5.7) or a superiority about one-fifth as great as that shown by Group A pupils when compared with Group C pupils in the upper half in intelligence, but it does not mean that the superiority is only one-seventh as great as

TABLE XI

| | Actual Mean Scores | | | |
|---|---|---|---|---|
| | (*a*) | (*b*) | (*c*) | (*d*) |
| **Group A** | | | | |
| Total scores | 50.5 | 64.8 | 52.4 | 63.3 |
| Geometry originals | 16.0 | 16.0 | 15.8 | 16.2 |
| Science review | 12.5 | 15.6 | 15.1 | 16.6 |
| Geometry review | 4.0 | 6.2 | 3.9 | 6.3 |
| Reading review | 14.0 | 16.8 | 12.4 | 16.6 |
| **Group B** | | | | |
| Total Scores | 70.0 | 96.8 | 74.8 | 87.8 |
| Geometry originals | 13.6 | 18.8 | 14.8 | 16.4 |
| Science review | 17.0 | 21.6 | 17.0 | 19.0 |
| Geometry review | 6.6 | 8.6 | 8.0 | 9.0 |
| Reading review | 17.0 | 22.8 | 19.2 | 20.4 |
| **Group C** | | | | |
| Total scores | 35.7 | 43.3 | 37.0 | 35.8 |
| Geometry originals | 6.5 | 12.7 | 8.8 | 10.9 |
| Science review | 11.3 | 10.0 | 10.8 | 10.8 |
| Geometry review | 5.5 | 3.3 | 3.9 | 3.0 |
| Reading review | 6.0 | 9.3 | 6.2 | 5.7 |

(*a*) Pupils in the lowest 25 per cent in intelligence.
(*b*) Pupils in the highest 25 per cent in intelligence.
(*c*) Pupils in the lower half in intelligence.
(*d*) Pupils in the upper half in intelligence.

TABLE XI (Continued)

| | Comparing Group Means | | Comparing Intelligence Levels | | | |
|---|---|---|---|---|---|---|
| | Actual Difference | Significance Ratio | (a) | (b) | (c) | (d) |
| **Comparing A with B** | | | | | | |
| Total score | − 23.5 | 8.2 | − 19.5 | − 32.0 | − 22.4 | − 24.5 |
| Geometry originals | 0.5 | 0.7 | 2.4 | − 2.8 | 1.0 | − 0.2 |
| Science Review | 1.9 | 2.3 | − 4.5 | − 6.0 | − 1.9 | − 2.4 |
| Geometry Review | − 3.3 | 5.0 | − 1.4 | − 2.4 | − 4.1 | − 2.7 |
| Reading | − 5.4 | 4.8 | − 3.0 | − 6.0 | − 6.8 | − 3.8 |
| **Comparing A with C** | | | | | | |
| Total score | 21.1 | 7.6 | 14.8 | 21.5 | 15.4 | 27.5 |
| Geometry originals | 6.2 | 7.0 | 9.5 | 3.3 | 7.0 | 5.3 |
| Science Review | 5.1 | 5.9 | 1.2 | 5.6 | 4.3 | 5.8 |
| Geometry Review | 1.6 | 2.2 | − 1.5 | 2.9 | 0.0 | 3.3 |
| Reading | 8.5 | 7.9 | 8.0 | 7.5 | 6.2 | 10.9 |
| **Comparing B with C** | | | | | | |
| Total score | 44.6 | 15.5 | 34.3 | 53.5 | 37.8 | 52.0 |
| Geometry originals | 5.7 | 6.3 | 7.1 | 6.1 | 6.0 | 5.5 |
| Science Review | 7.0 | 9.1 | 5.7 | 11.6 | 6.2 | 8.2 |
| Geometry Review | 4.9 | 7.5 | 1.1 | 5.3 | 4.1 | 6.0 |
| Reading | 13.9 | 14.1 | 11.0 | 13.5 | 13.0 | 14.7 |

(*a*) Pupils in the lowest 25 per cent in intelligence.
(*b*) Pupils in the highest 25 per cent in intelligence.
(*c*) Pupils in the lower half in intelligence.
(*d*) Pupils in the upper half in intelligence.

that shown for the same pupils in questions dealing with reading, the latter difference being 8.0. This, however, can be said: that the superiority of Group A over Group C is relatively less for pupils of high intelligence for the science review questions than for the reading questions.

From these data we may conclude that in so far as answers to these questions indicate the extent to which pupils knew what was to be done:

1. With the exception of facts dealing with solving originals and possibly reviewing for an examination in science, Group B knew better what was to be done than Group A.

2. Both Group A and Group B knew equally well what was to be done in solving originals, but pupils in Group A of below average intelligence knew these facts better than the pupils in Group B of similar intelligence, and Group B pupils of above average intelligence knew these facts slightly better than Group A pupils of similar intelligence.

3. Pupils of all intelligence levels in Group A knew equally well what to do in the solution of originals.

4. In all other cases Group A and Group B pupils of above average intelligence knew better what was to be done than pupils of below average intelligence.

5. Pupils of all intelligence levels in Group C knew equally well what to do in reviewing for an examination in science.

6. The technique used in reviewing for an examination in geometry did not materially tend to improve with Group A a knowledge of what was to be done. This probably accounts for the failure to get results in this study situation, and is no doubt due to poor teaching on the part of the writer, inadequate time, or the selection of the wrong elements to insure success.

*Effect on Formation of Study Habits.*—We have no way of measuring study habits except in the immediate product of the study method used, which is an inadequate measure of the habit itself. We cannot therefore say that better study habits resulted from the use of either experimental factor. In fact, the writer feels safe in stating that very little, if any, actual new and permanent study habits resulted, with the possible exception of the study situation first used—solving originals in geometry. In such study situations which find the pupil on the plateau of his learning curve new permanent study habits cannot be developed in a period of time as short as that in which these experimental factors were used. However, if we are to accept the physiological basis of habit formation as the explanation for the existence of habits we must believe that the more a particular study method is used, provided its use is accompanied with satisfaction, the more likely will that study method become a habit.

## GENERALIZATIONS

In generalizing from the data at hand certain facts must be kept in mind.

1. The number of pupils used was too small to permit the

results to be thought of as being conclusive; it would be better to speak of them as being indicative.

2. The situation in which the experiment was conducted was artificial, and although the writer constantly aimed to provide the most natural setting possible, he does not feel that he accomplished this in its entirety.

3. The conclusions which can be drawn from each of the several study situations used and the several measures employed, with a few minor exceptions, tend to corroborate each other.

4. In spite of the small number of cases and the rather great variation shown in any one group, the differences found in favor of our general corroborating data are great enough to be classed as highly significant in some cases, if the ordinary statistical methods are used for determining the significance of results, and in most of the remaining cases the significance, although not high, shows odds within a range of 4 to 1 and 22 to 1 and may, therefore, be classed as indicative.

Having these conditions in mind the writer feels safe in drawing the following generalizations: If we are to view high school education as now almost exclusively viewed, as a certain number of prescribed courses of study so organized as to intend to prepare the pupil for certain future life activities, and these courses in content and aim will be substantially the same for all pupils who have sufficient ability to maintain an existence in our high schools, then—

1. The technique used in developing proper study habits among pupils at one end of the intelligence scale must be different from that used for pupils at the other end of the intelligence scale: (*a*) pupils of high intelligence can generally be depended upon to translate information into action if the activity is properly motivated and the pupils are held strictly accountable for a certain degree of mastery; (*b*) pupils of low intelligence need a great deal of practice material used in its proper setting and consisting of the elements of a given study situation arranged in the order in which they are to be used in their ordinary study.

2. Both groups of pupils are materially helped by an analysis of a study situation into its elements and the presentation of these elements to the class. The difference between the two groups consisting of a difference in the method of presentation: (*a*) the group of high intelligence needs a clear demonstration of the use

of the elements of the study situation with only sufficient practice to check upon the clarity of the demonstration; (*b*) the group of low intelligence needs systematic practice in the use of the study situation; such practice requires a motor response for each step, followed by a checking of the correctness of the motor response, so arranged that both teacher and pupil may know the progress made in the use of the study situation.

3. The more the technique for creating better study habits is used in connection with and as a part of the daily recitation, the greater is the probability of success.

4. The farther removed from the plateau of his learning curve in the particular study situation that a pupil is found, the better is the possibility of developing in the pupil the use of the correct study habit.

5. The difference in treatment of the pupils of the two extremes in intelligence is not to be thought of as dividing the whole school population into two types, but rather that the two extreme ends of the distribution are so different that different remedial treatment is required and that these differences become less pronounced as the two groups approach each other in intelligence. This would mean that the problem of determining the type of remedial treatment required becomes an individual problem for pupils of average intelligence and that the amount of practice or the amount of demonstration is not to be determined by the fact that the pupil's intelligence rating places him in the second or third quarter of the distribution, but by the fact that he demonstrates either proficiency or lack of proficiency in his attack upon the study of new material involving the use of the particular study situation in which proficiency is desired.

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# APPENDIX

## OUTLINE OF "HOW TO STUDY" COURSE FOR GROUP B

I. Habit formation.

Purpose—to acquaint pupils with physiological basis of habit formation, and at the same time to give specific material for notetaking, which notes are to form the basis for discussion of the next topic.

A. Structure of nervous system.

B. Properties of neurones.

Impressibility, conductivity, and modifiability.

C. The control of habit formation.

1. Will to do.
2. Emphatic start.
3. No exceptions.
4. Seize every opportunity to act on resolution.

D. Why make behavior habitual.

1. To become more accurate.
2. To become more consistent.
3. To make life easier.
4. For economy.
5. To keep mind free for higher activities.

II. Notetaking.

Purpose—to apprise pupils of purpose and value of notes and to give them a series of suggestive helps.

A. Notes are good when:

1. The one taking them has a specific purpose in mind.
   *a.* To create better mental impression.
   *b.* To have material in good form for study.
   *c.* To have material for future reference.
2. The taking of them is accompanied by logical and efficient thought, and is not used as a substitute for thought.

B. Kind of notes.

1. Lecture, reading, thoughts and reveries.
2. Adaptation of notetaking to mathematics, science, English, and foreign languages.

C. Suggestive technique.

1. Develop a shorthand code.
2. Use diagrams, labelled whenever possible.
3. Always use your own words, unless author's words should be memorized.
4. Adopt a logical outline system and adhere to it consistently.

5. Try to grasp the lecturer's or author's sense and put it into your own words.
6. Don't write until you have a real thought.
7. Carry a pocket notebook in which to jot notes of worthwhile thoughts, which should be jotted down as soon as they come to your mind.
8. Peruse notes and elaborate mentally on them just as soon after making them as possible.
9. Review these notes again before taking up advanced work.

III. Examinations.

Purpose—to apprise pupils of factors which determine success in taking examinations.

A. Why take examinations?
   1. Test a knowledge of certain facts.
   2. Test ability of application of facts.
   3. Test what pupil knows and doesn't know.
   4. Serve as an incentive to harder work.
   5. Help pupils to link up facts in a new way.
   6. Serve as incentive to view work covered as a whole.

B. How to prepare for examination.
   1. Conscientious, thoughtful study day by day.
   2. Keeping notes posted up in brain.
   3. A periodic (weekly or monthly) review.
   4. Know the personality of the examiner.
   5. Review carefully the high points in the material covered by examination, and memorize an outline of it.
   6. Have body in best physical condition (sleep, eating, etc.).
   7. Look over entire material for a final impression just before the examination hour.

C. How to take the examination.
   (Kitson gives 10 criteria and Dearborn 13.)

D. Specific directions applicable to mathematics, English, science, history, and foreign languages.

IV. Getting the best out of one's reading.

Purpose—to apprise pupils of those reading attitudes and habits which are generally considered the best.

A. Have a specific purpose, knowing:
   1. When to skim.
   2. When to read carefully.
   3. What is the desired sought information.
   4. What to omit.

B. Use of textbooks.
   1. Always use more than one book for each subject.
   2. Use these books to form your own opinion of the assigned topic rather than to memorize what the author says.
   3. If possible, mark important parts in book, and for reviewing pur-

pose use notebooks in which to record the gist of the lesson, having in mind written notetaking only as an aid to mental notetaking.

C. Use of other books.
   1. Should be read with a single aim in mind.
   2. Consult preface to learn aim of author.
   3. Consult table of contents to determine how best to achieve the desired aim.
   4. Then skim or read carefully depending upon the aim selected.

D. In general.
   1. When reading with detailed study in mind be able to express in your own words the thought of each paragraph before going on to the next, and if necessary for retention write out the thought of each paragraph.
   2. Dictionary habit.
   3. Notetaking habit (or marking book).
   4. Encyclopedia or reference habit.
   5. Read critically.
   6. Turn over in your mind what has been read as soon after reading it as possible.
   7. Value of collateral reading as a means of subconscious learning.
   8. Be familiar with the author and his purpose or plan.

V. Memory.

Purpose—to develop the correct attitude toward memory and the improvement in its use.

A. Impression—how to secure the best.
   1. Go slowly in impressing material at first.
   2. Get a clear impression of how the word sounds or looks.
   3. Select the sense organ through which impressions are best made.
   4. It is sometimes well to bring several sense organs into play to make a good impression.
   5. Make more than enough impressions to insure recall (immediate vs. deferred recall).
   6. Know how to distribute the repetitions to get the most efficient results.
   7. A rest taken between impressions results in more permanent fixation.
   8. After first impression do not introduce anything immediately into the mind that may upset it.
   9. Impressions are fixed unconsciously through association of the thing learned to everyday life. Write down impressions as they come to you, no matter how heterogeneous they are.
   10. Memorizing in part vs. whole.
   11. In foreign languages scrutinize a new word to get association with other words already known.

B. Retention—is entirely a physiological process dependent upon nature and quality of impression.

C. Recall—make part of memorizing a rehearsal of it, preferably in

same setting and under same conditions in which final recall is to be made—in memorizing significant material more than half the time should be devoted to rehearsal or practicing recall.

D. Recognition—an attitude of confidence necessary—this will result only by meeting the conditions for memory.

E. Adaptation of above to mathematics, English, science, history, and foreign languages.

VI. Physical conditions that are conducive to the best study habits. (Kitson and Whipple enumerate many of these.)

## GEOMETRY INTRODUCTORY SHEET

Those who solve geometry propositions with the least trouble find that their mind passes through certain *distinct* steps, these steps being taken one at a time until the solution of the proposition is complete. When one becomes an expert in solving geometry propositions his mind passes through those steps so rapidly that he is not conscious of it unless he afterward tries to recall what he actually did. At first, however, until the *correct habit* is firmly rooted in one's mental action, it is necessary to *go slowly*, keeping in mind each step; in time it will not be necessary to think of each step taken, for this will become an unconscious habit, and it is always *economical* in study to develop a large number of correct unconscious habits; this leaves one free to use one's thinking processes for the more difficult operations in study. The time required to form a correct habit depends on the conscious effort one puts forth in trying to make the correct habit.

The accompanying "Instruction Sheet" explains the steps to be used in solving all geometry propositions, and illustrates each step. Use this "Instruction Sheet" as a guide for all future practice work in geometry.

Keep your own scores for each Step in your notebook. This will serve as a guide of your progress.

Remember the *first* requirement for successful habit formation is a WILL (determination) to form the habit; the *second* requirement is a conscious EFFORT to succeed; and the *third* requirement is the use of every opportunity to EXERCISE the habit.

Economical study means more accomplished and a better quality of work done in less time.

## INSTRUCTION SHEET A

### Geometry

The following sample proposition is used in these instructions:

1) "The diagonals of a parallelogram bisect each other."

*Step 1:* Purpose—to select from the proposition "what is given" and "what is to be proved."

1) Given—diagonals of a parallelogram.
   To prove—the diagonals bisect each other.

(Notice that in this proposition it is necessary to repeat the word "diagonals"

under "to prove" in order that what is said under "to prove" will make sense. Be careful that each statement made states a complete thought.)

On Sheet 1 you will find propositions similar to the one given above. In the proper spaces under each proposition write what is asked. When this is done ask for the checking sheet; check your own answers using "C" for correct and "X" for wrong. Place your score, expressed in "per cent right," on the line which is marked "Score" and keep a copy of the score for yourself.

*Step 2:* Purpose—to know what each significant word in the proposition means.

1) 1. Diagonals.
   2. Parallelogram.

(Notice that after the number of the proposition originally given, (1), two words are placed and a line is drawn under the last word. This means that the pupil who is taking this drill work is not certain of the meaning of these two words, which of course means that he must look them up before he can go on.)

Sheet 2 consists of an ordinary sheet of composition paper on which you will place your name and a blank for the score. You will find the directions for the first part of this step on the bottom of Sheet 1. Carry out these instructions; then write on Sheet 2, under the line drawn under the last word not known, the definitions for the words found on the board.

When this is done call for the correction sheet. Check your papers and then score as follows: Divide the total number of words first written on the sheet (above the line) by the total number of definitions "not correct" and express this fraction in per cent. Place this Score on the line reserved for this purpose; keep a record of the score for yourself under the head of "Certainty of new words."

*Step 3:* Purpose—to analyze the propositions into parts necessary to construct the figure.

1) 1. Parallelogram.
   2. Diagonals.

(Notice that two words have been placed after the number of the proposition originally given. These words mention the particular things which must be known to draw the figure. Sometimes a phrase may have to be used instead of a word, such as, "parallel to the base," or the like. In every case name, under each proposition, all the separate things which have to be drawn to complete the figure.)

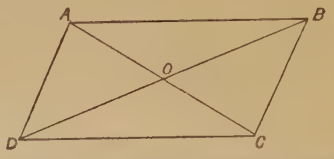
Sheet 3 will consist of a sheet of composition paper on which you will place your name and below it, first, "Analysis Score" . . . .

and then, "Figure Score" . . . .

The directions for *Step 3* will always be the same: "Place numbers from 1 to 5 along the left-hand margin at least four lines apart. After each number list the several things which have to be drawn to complete the figure; draw a line under the last word written for each proposition." Ask for the checking sheet and check your answers. The score is obtained by dividing the number right by the number found at the bottom of the checking sheet; express this

score in per cent. Place this score in the space provided for "Analysis Score" and keep a record of your score under the same heading.

*Step 4:* Purpose—to draw the figure.




Draw the figure near the right side of Sheet 3, to the right of the words enumerated under each proposition on Sheet 3. Call for checking sheet. Any mistake in the figure (omission of line or drawing it so carelessly that the intent of the drawing is not clear to the examiner) makes the whole drawing wrong. The "Figure Score" for this step is the per cent of figures correctly drawn. Keep a record of your score and place the score on Sheet 3.

*Step 5:* Purpose—to outline what must be done to prove the proposition.

(Sheet 4 consists of a sheet of composition paper prepared with name and numbers like Sheet 3. A space is also provided for the score.)

1) I can prove the diagonals bisected if I can prove the triangles *AOB* and *DOC* equal.

I can prove these triangles equal if I can get (*a*) three sides of one equal to three sides of the other, or (*b*) two sides and included angle of one equal to two sides and included angle of the other, or (*c*) two angles and included side of one equal to two angles and included side of the other.

(You will notice that in making the above statement the pupil first kept in mind what was to be proved according to *Step 1;* then he recalled in his mind under what conditions this could be proved; and, finally, he recalled under what conditions the last named condition could be proved. This must be continued until you get to something which you know to be true from the facts which were listed under "Given" in *Step 1.* In this case the pupil knew that *DC* and *AB* are parallel and equal because the figure is given as a parallelogram; this fact helps him to prove the triangles equal and knowing this helps him to show that the segments of the diagonal are equal.)

After having completed the above on Sheet 4 call for the checking sheet, and score your paper on the basis of the per cent right, using the number at the bottom of the checking sheet as the total possible right.

Place this score in the proper place and keep a record of it for yourself under "Analysis of proof."

PRACTICE SHEET 1 (*a*)

Name.....

Score.....

Proposition

1) Perpendiculars drawn from the midpoint of the base of an isosceles triangle to the legs are equal.
   Given:
   To prove:

2) If the midpoints of the legs of an isosceles triangle are joined to the midpoints of the base the figure thus formed is a rhombus.
   Given:
   To prove:

3) Perpendiculars drawn from an arbitrary point in the bisector of an angle to the side of the angle are equal.
Given:
To prove:

4) A diagonal of a parallelogram is trisected by the lines joining the other two vertices with the midpoints of the opposite sides.
Given:
To prove:

5) If the median of a triangle equals one-half the side it bisects the triangle is a right triangle.
Given:
To prove:

NOTE: When entirely finished with *Step 1* (see "Instruction Sheet") take Sheet 2 and write all the words found in the above propositions of whose definition you are not absolutely certain. Number these words and draw a line under the last word written. Then carry out the other directions given under *Step 2* of the "Instruction Sheet."

## CHECKING SHEET 1 (*a*)

1) Given: perpendiculars drawn from the midpoint of the base of an isosceles triangle to the legs.
To prove: the perpendiculars are equal.

2) Given: the midpoints of the legs of an isosceles triangle are joined to the midpoints of the base.
To prove: the figure thus formed is a rhombus.

3) Given: perpendiculars drawn from an arbitrary point in the bisector of an angle to the sides of the angle.
To prove: these perpendiculars are equal.

4) Given: a diagonal of a parallelogram with lines joining the other two vertices with the midpoints of the opposite sides.
To prove: the diagonal is trisected.

5) Given: the median of a triangle equal to one-half the side it bisects.
To prove: the triangle is a right triangle.

## CHECKING SHEET 2

1) Triangle—rectilinear figure of three sides.
2) Isosceles triangle—a triangle with two sides equal.
3) Quadrilateral—rectilinear figure of four sides.
4) Parallelogram—quadrilateral with opposite sides parallel.
5) Rhombus—parallelogram with two adjacent sides equal.
6) Trapezoid—quadrilateral with two sides parallel.
7) Legs of isosceles triangle—equal sides of triangle.
8) Legs of right triangle—sides forming the right angle.
9) Arbitrary—at any point selected.
10) Hypotenuse—side opposite the right angle of a right triangle.
11) Bisected—cut into two equal parts.

12) Trisected—cut into three equal parts.
13) Equidistant—equal distance.
14) Transversal—one line cutting two or more lines.
15) Intercept—cut off.
16) Rectangle—parallelogram with all angles right angles.
17) Distance from point to a line—length of perpendicular from point to that line.
18) Polygon—rectilinear figure of three or more sides.

## CHECKING SHEET 3 (*a*)

1) 1. Isosceles triangle.
   2. Midpoint of base.
   3. Perpendiculars from this point to the legs.

2) 1. Isosceles triangle.
   2. Midpoints of the legs.
   3. Midpoint of the base.
   4. Two lines joining midpoints of legs with midpoint of base.

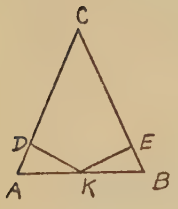
3) 1. An angle.
   2. A bisector of the angle.
   3. Any point in the bisector.
   4. Perpendiculars from this point to the sides.

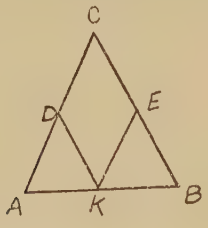
4) 1. Parallelogram.
   2. One diagonal.
   3. Lines drawn from other two vertices to midpoint of opposite sides.

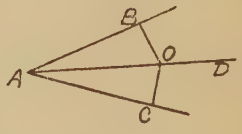
5) 1. Triangle so drawn that its median equals one-half the side it bisects.
   2. The median.

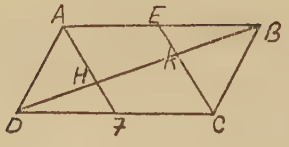
16 (Total number of items)

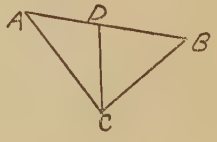
## CHECKING SHEET 4 (*a*)



## CHECKING SHEET 5 (*a*)

1) 1. I can prove perpendiculars equal if I can prove small right triangles thus formed congruent.

2. I can prove these triangles congruent if I can prove either (*a*) hypotenuse and acute angle, or (*b*) hypotenuse and leg, or (*c*) two legs, respectively equal.

2) 1. I can prove figure a rhombus if I can prove it a parallelogram with adjacent sides equal.

2. I can prove it a parallelogram by proving opposite sides parallel or two opposite sides both equal and parallel.

3. I can prove opposite sides parallel either by proving certain angles equal or by showing that one of these sides bisects two sides of a triangle of which the other side is the base.

4. I can prove two adjacent sides equal by proving small triangles congruent.

5. I can prove these congruent either by *SAS*, *SSS*, or *ASA*.

3) 1. I can prove perpendiculars equal if I can prove the right triangles thus formed congruent.

2. I can prove these triangles congruent the same as in original 1 above.

4) 1. I can prove diagonal trisected if I can prove its three segments corresponding parts of congruent figures or intercepted by parallel lines which cut equal segments on another line.

5) 1. I can prove triangles right if I can prove angle opposite the side bisected a right angle.

2. I can prove this a right angle if I can prove it equal to the sum of the other two angles of the large triangle.

3. I can prove this if I can prove the two triangles formed isosceles.

16 (Total number of items)

## INSTRUCTION SHEET B

* *Step 1:* Purpose—to select from the proposition "what is given" "what is to be proved."

*Directions:* Underline once the part of the sentence which states "what is given" and twice the part of the sentence which states "what is to be proved," placing short vertical strokes at the ends of the line to indicate where you intend them to stop.

If two parallel lines are cut by a transversal the alternate angles are equal.

If part of "what is given" must be repeated to indicate in full "what is to be proved," draw two extra lines under this part.

The diagonals of a parallelogram bisect each other.

* *Step 2:* Purpose—to make certain that you know the meaning of each significant word in the proposition.

* Steps are starred to make them prominent for skimming.

*Directions:* Read slowly the proposition on which you are working and if you meet a word of whose meaning you are in doubt place a check (√) over the word, and continue reading until you have treated each doubtful word in this way. Example:

If two parallel lines are cut by a transversal the alternate angles are equal.
√ √

This means that the reader is in doubt of the meaning of "transversal" and "alternate." Having marked your own proposition in this way look up the meanings of the doubtful words and write them on the back of the proposition sheet.

* *Step 3:* Purpose—to analyze the proposition into parts necessary to draw a figure.

*Directions:* Decide what geometric figure you would have to draw first if you were going to draw a complete figure with which to prove your proposition. Place parentheses around the word or words describing in full this first drawing operation and place a one (1) above them. Then enclose the words of the second drawing operation in parentheses and place a two (2) above them, etc., until you have treated in this manner every possible distinct drawing operation of your proposition.

The (diagonals[2]) of a (parallelogram[1]) bisect each other.

If the words necessary to describe a complete drawing operation appear in such an order in the proposition that it is not possible to enclose them in parentheses without including other words then write below the proposition (after a number indicating the number of the drawing operation) the words necessary to describe in full this particular operation. If the (midpoints[3] of the legs) of an (isosceles[1] triangle) are joined to the (midpoint[3] of the base); the figure thus formed is a rhombus.

[4] "Midpoints of legs are joined to midpoint of base."

(Notice that the words following four (4) are necessary to complete the figure but are so arranged in the proposition that they cannot be enclosed in parentheses without including words not needed.)

* *Step 4*: Purpose—to draw the figure.

Draw the figure as accurately as the eye permits. You need not letter it, but never draw a special figure when a general figure is asked for. (Never draw a parallelogram if only a quadrilateral is mentioned, nor an isosceles triangle when a triangle is mentioned.)

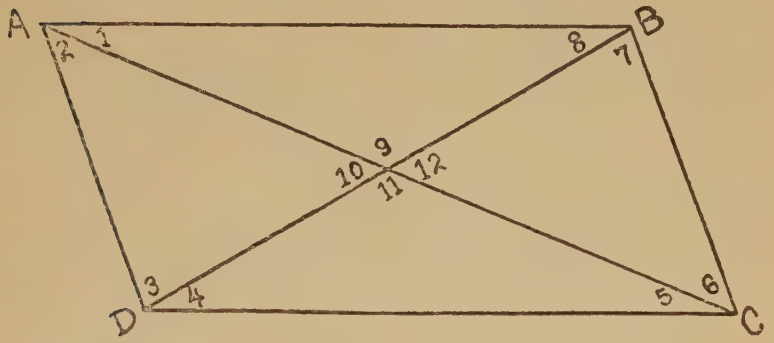
*Checking:* Check your work on the basis of per cent right, placing the score in the space provided for this purpose. Leave the checking of *Step 2* for the teacher. Possible scores: for *Step 1*, 0, 50 or 100; for *Step 4*, 0 or 100.

**Step 5:* Purpose—to recall all significant facts about the figure which are known to be true.

*Directions:* Using a clean sheet of composition paper, state all facts known about the figure, placing each known fact on a separate line after a number, so that when you are through you could refer to separate facts by numbers. Underline those facts which you think are most likely to help you in proving the proposition. Example:—

The diagonals of a parallelogram bisect each other.

| | | |
|---|---|---|
| 1. $AB = DC$ | 5. $\angle 3 = \angle 7$ | 9. $\angle 1 + \angle 2 = \angle 5 + \angle 6$ |
| 2. $AD = BC$ | 6. $\angle 4 = \angle 8$ | 10. $\angle 3 + \angle 4 = \angle 7 + \angle 8$ |
| 3. $\angle 1 = \angle 5$ | 7. $\angle 9 = \angle 11$ | 11. $AB$ is // to $DC$ |
| 4. $\angle 2 = \angle 6$ | 8. $\angle 10 = \angle 12$ | 12. $AD$ is // to $BC$ |




*Checking:* Place the checking sheet alongside of your work and note only those facts on the checking sheet which are underlined. Place a two (2) after each underlined fact on your sheet which corresponds to the underlined facts on the checking sheet. Place a one (1) after each fact not underlined on your sheet which corresponds to a fact that is underlined on the checking sheet.

Place a minus two (–2) after each underlined fact on your sheet which does not at all appear on the checking sheet; and place a minus one (–1) after each other fact on your sheet which does not appear on the checking sheet. Disregard all other facts mentioned on the checking sheet as well as any identities which you may have mentioned on your sheet. Get the algebraic sum of these numbers. Divide this sum by the "possible score" appearing at the top of the checking sheet and express the fraction in per cent. This is your score for *Step 5*.

* *Step 6:* Purpose—to determine the probable course of procedure in proving the proposition.

*Directions:* Referring to the proposition and figure used in *Step 5*, notice that we want to prove $AO = OC$ and $DO = OB$. Lines can be proved equal if they can be shown to be parts of congruent figures. These lines will therefore be equal if we can prove triangles $AOB$ and $DOC$ congruent. In *Step 5* we have facts 1, 3, and 6, which will be sufficient to prove the triangle congruent.

This can be easily stated as follows:

| I can prove | if I can prove | This is true because of the following facts in *Step 5:* |
|---|---|---|
| $AO = OC$ | $\triangle$ $AOB$ and $DOC$ congruent | 1, 3, and 6 |

It is not always possible to outline a proof so directly as the above proof is outlined. Sometimes the first statement under the second column cannot be proved until we prove some other fact first. For example, suppose we let *A*, *B*, *C*, and *D* represent certain facts about a figure all of which require the use of some facts in order to be proved true; and let *x*, *y*, and *z* represent the facts which we know to be true from *Step 5;* then we would have the following for *Step 6:*

| I can prove | if I can prove | This can be shown to be true because of the following facts from *Step 5*: |
|---|---|---|
| 1. *A* | *B* | |
| 2. *B* | *C* | |
| 3. *C* | *D* | x, y, z |

*Checking:* Each statement in columns headed "I can prove" and "If I can prove" combined is given a score of two (2), and each complete statement in column headed "this can be shown . . . " is given a credit of 2.

The total credit for the last-mentioned sample would be 2 for the first statement, plus 2 for the second statement, plus 2 for the third statement, plus 2 for the statement in the last column (x, y, z) or a total credit of 8.

The score for your proposition is determined by dividing the sum obtained as mentioned above by the "possible score," always written at the head of the checking sheet, and expressing this fraction in per cent.

NOTE: After you have finished checking *Step 6* and have not received a score of 100, determine why you made a mistake and then state on your paper why you think you are wrong and the checking sheet is right, or, if you think the checking sheet is wrong and you are right, give a reason for your answer.

PROPOSITION 1 (*m*)

Name.....

If one diagonal of a quadrilateral bisects the angles at the vertices which it joins the diagonals of the figure are perpendicular to each other.

Figure:

Score: Step 1.....Step 2.....
Step 3.....Step 4.....

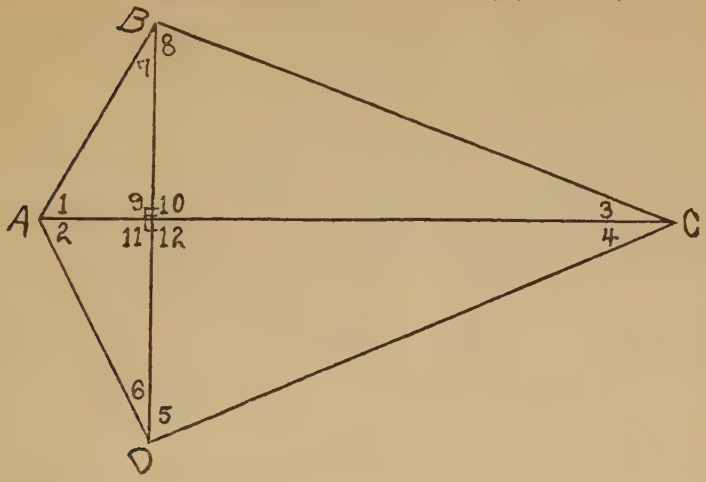
CHECKING SHEET 1 (*m*) to 4 (*m*)

If (one[2] diagonal) of a (quadrilateral[1]) bisects the angles at the vertices which it joins, the diagonals of the figure are perpendicular to each other.

[3] One diagonal bisects the angles at the vertices which it joins.
[4] Other diagonal.

[*Drawing for this figure is shown on next page*]

CHECKING SHEET 1 (*m*) to 4 (*m*) (*Continued*)




Note: Drawing part 2 may be omitted if part 3 is correct and credit given on the basis of a total of three parts.

CHECKING SHEET 5 (*m*)

POSSIBLE SCORE—4

1. $\angle 1 = \angle 2$.
2. $\angle 3 = \angle 4$.

CHECKING SHEET 6 (*m*)

POSSIBLE SCORE—10

| I can prove | If I can prove | This is true because of the following facts in *Step 5:* |
|---|---|---|
| 1. $BD \perp$ to $AC$ | $\angle 9 = \angle 11$ | |
| 2. $\angle 9 = \angle 11$ | $\triangle$ *ABE* and *ADE* are congruent | |
| 3. $\triangle$ are congruent | $AB = AD$ | |
| 4. $AB = AD$ | $\triangle$ *ABC* and *ADC* are congruent | 1 and 2 (*AC* being common) |

Alternate Method: Instead of working with triangles *AEB* and *AED* and sides *AB* and *AD* use triangles *BEC* and *DEC* and sides *BO* and *DC*. Otherwise the two proofs are the same.

GEOMETRY ORIGINALS USED FOR FINAL TESTING

1) Perpendiculars drawn from the extremities of a side of a triangle to the median upon that side are equal.

2) If two medians of a triangle are equal the triangle is isosceles.

3) If from the point where two altitudes of an isosceles triangle meet a line is drawn to the vertex it bisects the angle at the vertex.

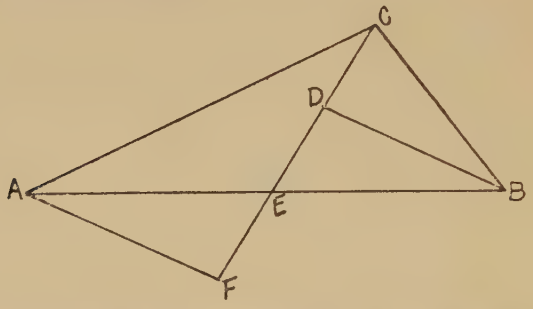
4) If two circumferences are tangent internally and the radius of the larger is the diameter of the smaller then any chord of the larger drawn from the point of contact is bisected by the circumference of the smaller.

5) If two triangles are inscribed in a circle and two sides of one are parallel to two sides of the other the third sides are equal.

6) $BC$, a chord of a circle, is the base of an isosceles triangle whose vertex, $A$, lies without the circle, the equal sides intersecting the circumference at $D$ and $E$. Prove $AD$ equal to $AE$.

## METHOD OF SCORING ORIGINAL NO. 1

Perpendiculars drawn from the extremities of a side of a triangle to the median upon that side are equal.




Given $AE = EB$ and $BD \perp$ to $CE$ and $AF \perp$ to $CE$ produced.
To prove $AF = BD$.

| Proof: | | *a* | *b* | *c* | *T** |
|---|---|---|---|---|---|
| 1)** $AE = EB$ | (given). | 1 | 1 | 2 | 4 |
| 2) $\angle 1 = \angle 2$ | (vertical angles). | 3 | 3 | 6 | 12 |
| 3) $\therefore \triangle AEF = \triangle DBE$ | (rt. triangle having hypotenuse and adjacent angle equal). | 2 | 2 | 4 | 8 |
| 4) $\therefore AF = DB$ | (corresponding sides of congruent triangles). | 1 | 1 | 2 | 4 |
| | | | | | 28 |

| | | |
|---|---|---|
| Figure score | 12 | (The difficulty arose in |
| Given score | 6 | producing the median). |
| To prove score | 6 | |
| Proof score | 28 | |
| | 52 | |

* *a* —score for correct statement.
*b* —score for statement in correct order.
*c* —score for correct reason for statement.
*T*—total score.

** Step 1 is a given step.
Step 2 is a link step of a simple type.
Step 3 is a therefore step built up from (1) and (2).
Step 4 is a therefore step following directly from (3).

## GENERAL SCIENCE REVIEW

To review a subject like General Science in preparation for an examination the subject matter should be reorganized or put together and examined or viewed in a way different from the way it was originally studied.

Originally you studied the General Science in small separate lessons, each closely related to the one which immediately preceded and also to the one which was to follow.

To review for the midyear examination one should therefore first view all the work covered as a "whole," and then divide this "whole" into parts, and each of these parts into still smaller parts, etc., until all the subject matter of importance has been included. The relationships which exist between the several parts can thereby be best seen.

This is best done by working the whole subject into an outline, the usual form of which is shown on the board on your left.

In outlining something for the first time one does not, however, proceed quite so logically. The first thing usually done is to divide the "whole" into a few big divisions without having in mind their content except in a general way. Then each of these big divisions is considered separately and divided into a few subdivisions, etc.

*Directions:* The contents of the Chapters I to VII inclusive and Chapter XI are readily grouped under five main heads. Therefore place, on the first five lines of a sheet of paper, words, phrases, or sentences which you would use in referring to these five big divisions. Use the Roman numbers of the outline to designate them as shown on the second board.

You will find that the first big topic is divisible into two or three parts, the second big division into three parts, the third into four parts, etc. Show these subdivisions of the big divisions on your paper as shown on the third board.

Next show the subdivisions of *A*, *B*, *C*, as shown on the fourth board.

From this point you may find it best to confine yourself to big division I, until you have outlined it down to separate lesson facts, and then proceed with big division II, etc.

Your work will be handed in at the end of the period and marked by me. Make note of the place where you stopped with your outlining and complete the remainder of the work between now and Wednesday and hand it in at the beginning of the class period.

NOTE: It is necessary for you to have outlined all of the eight chapters included in the examination before you can successfully continue with the review drill in General Science which we shall have to take at our next meeting.

## MODERN GLOVEMAKING

Most of our thinner "kid" gloves are made of lambskin; but dressing the skins is now done so skilfully in this country that "homemade" gloves are in many respects fully as good as the imported; indeed, some judges declare that in shape and stitching certain grades are better. When sheepskins and lambskins come to market from a distance they are salted. They have to be soaked in water, all bits of flesh scraped off, and the hair removed, generally by the use of lime. After another washing, they are put into alum and salt

for a few minutes; and after this is washed off, they are dried, stretched, and then are ready for the softening. Nothing has been found that will soften the skins so perfectly as a mixture of flour, salt, and the yolk of eggs—"custard," as the workmen call it. The custard and the skins are tumbled together into a great iron drum which revolves till the custard has been absorbed and the skins are soft and yielding. Now they are stretched one way and another, and wet so thoroughly that they lose all the alum and salt that may be left and also much of the custard.

Now comes dyeing. The skin is laid upon the table, smooth side up, and brushed over several times with the coloring matter; very lightly, however, for if the coloring goes through the leather, the hands of the customers may be stained and they will buy no more gloves of that make. The skins are now moistened and rolled and left for several weeks to season. When they are unrolled, the whole skin is soft and pliable. It is thick, however, and no one who is not an expert can thin it properly. The process is called "mooning" because the knife used is shaped like a crescent moon. It is flat, its center is cut out, and the outer edge is sharpened. Over the inner curve is a handle. The skin is hung on a pole, and the expert workman draws the mooning knife down it until any bit of dried flesh remaining has been removed, and the skin is of the same thickness, or rather, thinness, throughout.

All this slow, careful work is needed to prepare the skin for cutting out the glove; and now it goes to the cutter. There is no longer any cutting out of gloves with shears and pasteboard patterns, but there is a quick way and a slow way nevertheless. The man who cuts in the quick way, the "block-cutter," as he is called, spreads out the skin on a big block made by bolting together planks of wood with the grain running up and down. He places a die in the shape of the glove upon the leather, gives one blow with a heavy maul, and the glove is cut out.

This answers very well for the cheaper and coarser gloves, but to cut fine gloves is quite a different matter. This needs skill, and it is said that no man can do good "table cutting" who has not had at least three years' experience; and even then he may not be able to do really first-class work. He dampens the skin, stretches it first one way and then the other, and examines it closely for flaws or scratches or weak places. He must put on his die in such a way as to get two pairs of ordinary gloves or one pair of "elbow" gloves out of the skin, if possible, and yet he must avoid the poor places—if there are any. No glove manufacturer can afford to employ an unskilled or careless cutter, for he will waste much more than his wages amount to. There used to be one die for the right hand and another for the left, and it was some time before it occurred to anyone that the same die would cut both gloves if only the skin was turned over.

Now comes the sewing. Count the pieces in a glove, and this will give some idea of the work needed to sew them together. Notice that the fourchettes are sewed together on the wrong side, and the other seams on the right side, and that the tiny bits of facing and lining are hemmed down by hand. Notice that two of the fingers have only one fourchette, while the others have two fourchettes each. Notice how neatly the ends of the fingers are finished, with never an end of thread left on the right side. The embroidery must be

in exactly the right place, and it must be fastened firmly at both ends. This embroidery is not meaningless fashion, for the lines make the hand look much more slender and of better shape. Sewing in the thumbs needs special care and skill. There must be no puckering and the seam must not be so tightly drawn as to leave a red line on the hand when the glove is taken off.

No one person does all the sewing on a glove; it must pass through a number of hands, each doing a little. Even after all the care that is given it, a glove is a shapeless thing when it comes from the sewing machines. It is now carried to a long table with a rather startling row of brass hands of different sizes stretching up from it. These are heated, the gloves are drawn on and in a moment they have shape and finish—ready to be inspected and sold.

The glove is so closely associated with the hand and with the person to whom the hand belongs that in olden times it was looked upon as representing him. To throw down one's glove before a man was to challenge him to combat. At the coronation of Queen Elizabeth, as of many other sovereigns of England, the "Queen's champion," a knight in full armor, rode into the great hall and threw down his glove, crying, "If there be any manner of man that will say and maintain that our sovereign Lady, Queen Elizabeth, is not the rightful and undoubted inheritrix to the imperial crown of this realm of England, I say he lieth like a false traitor, and therefore I cast him my gage."

## THE TAPEWORM

Imagine an animal the width of a narrow ribbon and from twenty to forty feet long, living in your body, which you would have to feed every day, yes, three times a day. Such an animal, known as the tapeworm, has been known to live in the intestine of man.

A close examination of it shows that one end is very small and the other often from one-half to three-quarters of an inch wide. The smaller end is the head end. The head may be said to resemble a pear in shape with the biggest part of the pear in front and the stem end of the pear, the neck, which has fastened to it the body of the tapeworm. At the front end of the head there is a double row of usually about 28 curved and pointed hooks. The hooks are so small that they can be seen clearly only by the use of a microscope. The widest part of the head contains four cup-like projections placed at equal distances apart around the head, so that the tapeworm cannot be said to have a side, back or front of the head as man has. These cup-like projections are called suckers, and together with the aid of the hooks hold the tapeworm fast to objects on which it lives.

The narrow end of the pear-shaped head, the neck, has attached to it a long body which has a jointed appearance. Each of these parts between the joints or joint-like divisions of the body is called a segment or proglottide; there may be as many as 850 of these proglottides which become larger the farther away from the head they are, so that the largest proglottide is usually farthest from the head. Although the head is round or circular in appearance these segments are flat, and no difference can be seen between the two flat sides unless examined very carefully with the microscope, in which case enough difference can be seen that the tapeworm may be said to have a back and a front, or what is usually spoken of as a dorsal and ventral side.

If now we examine a live tapeworm and also put red-colored stain on the body of a preserved tapeworm so as to show up the internal organs better, we shall find that it has no alimentary canal or digestive system. Apparently the tapeworm does not digest its own food, but gets it already digested and only has to assimilate it. We shall, however, find an excretory system—a system which throws off waste matter—which is always formed in a living animal or plant. A trace of a nervous system is also found, but in place of a brain there are two small, not very well defined enlargements or ganglia, from which run two longitudinal nerves, running the full length of the body. Slender nerves also run to the suckers.

Reproductive organs are also present, a complete set in a proglottide, although these are not fully developed in any except the last segments. In fact, oftentimes no reproductive organs can be found until the 200th segment from the head is reached, showing that they develop first in the last segments.

The life-history of the tapeworm is interesting. It spends its adult life fastened to the intestine of man, with its head and its body lying loosely in the intestine. As the last segments develop or grow they finally drop off the rest of the body, one by one, and are passed out the intestine with waste matter. The embryo contained within the eggs now assumes the form of round bodies, each provided with six hooks. In this stage the tapeworm is known as the six-hooked embryo. If these now should be eaten by a pig they would bore themselves through the pig's digestive tract and finally lodge in its muscle or flesh, and there develop into a cyst or ball. While in the pig the embryo or young tapeworm, develops until it resembles its parent without the many proglottides, all, however, still encased in the cyst or ball. In this stage it is known as the bladder-worm stage. If this pig is killed and eaten by man without having been thoroughly cooked the tapeworm in this bladder-worm stage will get into the stomach of man, and there the outside covering of the ball or cyst is digested away so that the young tapeworm will be free to fasten itself to the walls of the intestine and develop hundreds and thousands of proglottides like those from which this young tapeworm developed. It will be noticed that its chance of getting back into man through the pig is very slight, so that each tapeworm must necessarily produce a very large number of young in order to continue its life-existence.

A person may have a tapeworm in his intestine without knowing it, the only evidence being an unusual appetite without seemingly getting nourishment from eating. If one knows that he has a tapeworm it is usually possible to rid the system of it by taking a strong oil cathartic—like castor oil—after a period of going without food. But unless the head of the tapeworm is evacuated from the system, the tapeworm will continue to grow and give annoyance to its host.

### SAMPLE OUTLINE

### MODERN GLOVEMAKING

I. Material used. 1
   A. Lambskins. 2
   B. Sheepskins.

II. Preparation of material.
  A. Curing the skins.
    1. Salted. 3
    2. Soaked. 4
    3. Flesh removed by scraping. 5
    4. Hair removed by lime. 6
    5. Washed. 7
    6. Placed in alum and salt. 8
    7. Washed a second time. 9
    8. Dried and stretched. 10
    9. Softened by absorption of mixture of flour, salt, and yolk of of egg. 11
    10. Final washing and stretching. 12
  B. Dyeing.
    1. Color brushed lightly over smooth side of skin. 13
    2. Moistened, rolled, and left several weeks to season. 14
  C. Thinning or "mooning."
    1. Skin made uniformly thin by crescent-shaped knife. 15

III. Cutting.
  A. Block-cutting, the quick way.
    1. Skin spread upon block. 16
    2. Die of glove placed upon leather. 17
    3. Cut with heavy maul. 18
  B. Table-cutting, the slow way for fine gloves.
    1. Skin dampened, stretched, and examined for flaws. 19
    2. Die placed on skin, avoiding weak places, yet preventing waste. 20

IV. Sewing.
  A. Seams.
    1. Fourchettes sewed together on wrong side. 21
    2. Other seams sewed on right side. 22
    3. Facings and lining hemmed by hand. 23
  B. Embroidery.
    1. In exactly the right place. 24
    2. Fastened firmly at both ends. 25
    3. To give grace to hand. 26
  C. Sewing in thumbs.
    1. Do not pucker seam. 27
    2. Do not draw seam too tightly. 28

V. Shaping—Drawn on heated brass hands. 29

VI. Inspection for market.

VII. Historic significance of the glove.
  A. Represented wearer. 30
  B. Challenge to combat. 31

OUTLINE OF "TAPEWORM"

I. External appearance.
  A. Size.
    1. Width of narrow ribbon. 1
    2. From 20 to 40 ft. long. 2
    3. One end very small, other end from ½ to ¾" wide. 3
  B. Head.
    1. Pear-shaped with big end of pear front. 4
    2. Double row of 28 curved and pointed hooks on front of head (only seen by use of microscope). 5
    3. Four cup-shaped suckers around widest part of head. 6
    4. Narrow (stem end) of pear-shaped head has body attached to it. 7
  C. Body—jointed in appearance.
    1. Divisions known as segments or proglottides.
      *a*. May have as many as 850. 8
      *b*. Become larger the farther they are from the head. 9
    2. Body flat with a dorsal and ventral side evident when seen under microscope. 10

II. Internal structure.
  A. Alimentary system.
    Absence shows that animal does not digest its own food. 11
  B. Excretory system—present. 12
  C. Nervous system.
    1. Brain consists of two poorly defined ganglia. 13
    2. Two longitudinal nerves run full length of body. 14
    3. Small nerves run to suckers. 15
  D. Reproductive system.
    1. A complete system develops in each proglottide. 16
    2. Most highly developed in last segments. 17
    3. Often none is seen in first 200 segments. 18

III. Life history.
  A. In man—adult stage.
    1. Fastened to intestine—head fast and body lies loose. 19
    2. Taken into system by eating poorly cooked pork. 20
    3. Taken into system as a fully developed embryo in a cyst. 21
    4. Cyst wall digested or dissolved off in stomach of man. 22
  B. Without a host—six-hooked embryo.
    1. Passed from intestine of man as single proglottide. 23
    2. Eggs in proglottide develop into a young embryo. 24
    3. Assumes form of a round body with six hooks. 25
  C. In pig—bladder worm stage.
    1. Eaten by pig and in this way gets into digestive tract. 26
    2. Bores its way through digestive tract into muscle of flesh. 27
    3. Forms a cyst and develops to appearance of head of parent. 28

IV. Treatment for tapeworm disease.
  A. Evidence—excessive appetite with no apparent benefit from food eaten. 29
  B. Removed by taking an oil cathartic. 30
    Head must be removed to be rid of worm. 31

## READING FOR THE PURPOSE OF STUDYING

An intelligent understanding of a lesson or assigned reading does not necessarily follow a thorough reading of the article; in fact, thorough reading as the first step is a waste of time in many cases, for how can one read understandingly unless he knows what he is looking for in his reading. In the first place, therefore, a lesson or article should be glanced over hurriedly to find out what it deals about. This hurried reading or skimming does not, however, mean a careless reading; it means rather a hurried reading with attention fixed on a few big things—the big points around which the article is built. Until you have selected these you cannot read the article with intelligence and efficiency.

The purpose of skimming, therefore, is the selection of a few main divisions of the article. A correct future reading and understanding of the details is determined by the care with which these main points are selected. Skimming must therefore be accompanied and followed by a careful thinking for the purpose of organizing ideas.

At first, therefore, our attention will be fixed on the selection of the main points of an article, and we shall give no concern to the details until later on.

The reader may sometimes find considerable difficulty with the opening sentence or paragraph, for it often does not seem to express a separate main point and it is difficult to place. Remember that not everything which is said in the article may belong to it, or it may be out of its correct place. Very few articles are written with perfection. On the other hand, the introductory remarks may refer in a few words to some thing or things which will be discussed in more detail later. The introductory statement, sentence, or paragraph, should therefore be read with the following possibilities in mind:

1. It may contain a rough outline of the contents of the article—it may give a clue to the main points.

2. It may give a gist of what was said before for the purpose of review and therefore have no reference to the article of which it is a part, except as a connecting link.

3. It may simply mention one thing of interest to be discussed with more detail later, but inserted here just to arouse interest.

4. It may be irrelevant to the contents of the article and is used simply to attract attention.

Paragraphs often serve as a guide post for the outline of the article, but these must not be depended on too closely, for paragraph breaks are frequently made to divide an otherwise lengthy and boresome discussion into smaller parts. Therefore, keep paragraphing in mind in looking for main points, but do not slavishly adhere to it.

The general scheme to follow in skimming is this:

1. Find out whether the introductory sentence or paragraph gives clue to the main points discussed.
2. Does the concluding paragraph give a summary of the article?
3. Read by paragraphs as much as possible but only as an aid in rapid reading.
4. Constantly have in mind your sole purpose—to find the main points in the article.
5. Remember that thinking must accompany skimming to detect main points, and must follow skimming to express these main points in the most concise and meaningful form.

## MATTER, WHAT IS IT?

Twenty-five centuries of time have brought about enormous changes in our conception of that which surrounds us and of which we ourselves are made, all due to the fact that man is not satisfied to accept things by faith, but is filled with an inner urge to satisfy a natural curiosity.

What is matter? Ancient man gave no more concern to this question than that which enabled him to create better dyes to ornament himself and his belongings, or make better tools with which to destroy his enemy, secure his food, or build his home. The Greek of the fourth and fifth century, B.C., however, extended his interest to speculation, and answered this question to his satisfaction when he believed that air, earth, fire, and water are the four elements comprising all matter.

For many hundred years this idea satisfied man, for although the alchemists of the Middle Ages conceived the idea that the royal metal, gold, could be made by the proper combination of common metals then known, the Greek conception of matter was not wholly discarded until the eighteenth century. In vain did the alchemist try to prove his theory and finally decided that he could accomplish his purpose only by the use of a magic substance which he called the "philosopher's stone," a form of conclusion which usually satisfies the man who doesn't know and is content with his lack of knowledge. The alchemist, however, never found his magic stone.

A revival of interest in the question, what is matter, came in the beginning of the eighteenth century when Stahl announced that a substance burns if it has "phlogiston" mixed with it, and will continue to burn until all the phlogiston has been used up. But, what is "phlogiston"? Well, he didn't know, but some things have it and some do not, and those that have it will burn and those which do not have it will not burn. In an effort to answer this last puzzling question the chemists of the eighteenth century finally discovered such substances as oxygen, nitrogen, and manganese. Other substances were discovered one by one, by breaking up the air, water, and earth, which the Greeks conceived as the simplest of all substances. So the Greek theory was exploded.

Chemists, therefore, began to think of substances or matter as of two kinds—elements, which cannot be further divided, and compounds which consist of a combination of two or more elements. Now we know the answer to the question, what is matter; it consists of many elements: some are gases,

some liquids, and others are solids, which cannot be further divided but which can be made to combine with each other under proper conditions. Satisfied? Not the scientist. He still had to answer the question, what is an element?

Now, whenever the scientist is faced with such a question he proceeds as follows: first, he looks around for a plausible explanation—an hypothesis; he supposes that such and such may be the case; secondly, he tries out his hypothesis on all the things to which it can be applied, to see whether it is true; thirdly, if he doesn't find that it fits entirely into all conditions into which it should apply he revises it to satisfy these misfits, and calls it a theory; fourthly, he tries out this new theory in all possible situations and when he finds no exceptions to his theory the world will accept it as law. But, while he is thus trying to verify his theory he often accidentally "falls upon" new problems which have to be solved even though his own theory will be established as a law.

This has happened since the early part of the nineteenth century in the scientist's endeavor to answer the question, what is matter? What is an element?

The English scientist, Dalton, and the Italian scientist, Avogadro, respectively propounded and verified what has been called the atomic theory as an explanation of the composition of elements and compounds. Dalton's theory may be summed up as follows: (1) "all elements are made up of minute, independent particles" which he called atoms; (2) "all atoms of the same element have the same masses, and all atoms of different elements have different masses"; (3) "when two or more elements unite to form a compound the action consists in the union of a definite small number of atoms of each element to form a small particle of the compound." The name molecule was given to a combination of atoms.

More than eighty different elements have been discovered up to the present time; therefore, according to Dalton, there must be more than eighty different kinds of atoms. But elements seem to vary among themselves; for example, sulphur has several different forms, each sulphur, but each somewhat different from its brother sulphur; so also does carbon have different forms; this is also true of other elements. Is it possible that each of these forms in which sulphur or carbon exists is composed of atoms which differ from the atoms which compose its brother sulphur or carbon? And if so, what is the difference between them? But no, there cannot be a difference between the atoms because it is possible to change one kind of sulphur into another kind of sulphur, or one kind of carbon into another kind of carbon; for example it is possible to make diamond (which is a form of carbon) from graphite (which is another form of carbon). Well, perhaps the atoms are arranged differently in these two forms of carbon, more compact, or something like that. And so the scientist continues his speculations.

Nearly ninety years after Avogadro verified Dalton's hypothesis, a physicist, Professor Thomson, came to the rescue by identifying what has been called the electron, a negatively charged particle. This discovery resulted from an attempt to explain the X-ray, and radium, the latter discovered by Madame Curie in 1898. The discovery of the electron fitted very well into the missing explanation for the atom's peculiarities. But, if the electron is a negatively

charged particle there must be associated with it a positively charged particle, thought the physicist. So he discovered the proton.

What are electrons and protons, and how does this discovery help us answer the question, what is matter? A complete answer to this question is a long story so we must content ourselves with only a sketchy statement. Let us therefore discuss the subject under three heads: description, peculiarities, and what is the relationship to atoms and molecules.

Suppose 200,000,000 atoms of hydrogen were placed side by side. The row would be about one centimeter or three-eighths of an inch long. But the electron is so small that it would have to be magnified 100,000 times to be as large as an unmagnified atom. A proton has a mass or weight 1850 times as great as that of the electron. Now, calculate this for yourself. Or, viewing it another way: Two little nitrogen atoms form a nitrogen molecule. With every breath we inhale a few score billion of these molecules, not to mention about one-fourth as many molecules of oxygen which are also in the air we inhale. These little molecules are moving in the air at about "1,000 miles an hour in a haphazard way; for on an average each can travel less than one-thousandth part of an inch before it must dodge another. That means a change of front about 50,000,000 times a second, and establishes a world's record in expediency."

These electrons and protons have two peculiarities: (1) because one is negative and the other positive they tend to attract each other in equal numbers, (2) but, since all electrons are negative and all protons positive, electrons tend to repel each other, and protons tend to repel each other. So these little bodies are possessed of two contrary ideas—a proton likes an electron, but it doesn't like another proton. The same is true of an electron.

The result is that they have grouped themselves into a great variety of ways, each form of grouping being a different kind of atom. For example, a nitrogen atom consists of 14 protons and 14 electrons, but 7 of these electrons are grouped together with 14 protons in the center of a sphere-shaped body, leaving the remaining 7 electrons to take care of themselves the best they can. This center is referred to as the nucleus of the atom. Two of the remaining electrons apparently are stationed a little distance away from this nucleus, one at each end, and together are known as the satellites. The remaining 5 electrons are distributed on the surface of the imaginary sphere. All together they form an atom of nitrogen.

It will be noticed that the nucleus of the nitrogen atom has an excess of 7 protons. An atom is recognized by the excess of protons in its nucleus; so helium has an excess of 2 protons, lead an excess of 82, etc. The highest possible number of excess protons is 92, but an atom of this many excess protons constantly disintegrates or breaks down, and is therefore unstable. This integration accounts for the peculiarities of radium, and a few other rare elements. But we must stop; not that we are finished with our story, but if we continue we shall get involved in the X-ray, the audion bulb, and radio, and that is too much for this trip.

Have we answered the question, What is matter? We've found that the Greek had a conception, which was at least more than his predecessor had, but the Greek conception did not satisfy; we were not satisfied with a division

of matter into elements and compounds, nor with a division of these into atoms and molecules. Are we going to be satisfied to call matter a group of electrons and protons? No, because what are electrons, and what are protons; what makes them different; what makes them group the way they do; what makes them move, etc., etc.? There is still plenty to learn, and plenty to be done. We have come nearer answering our question, just to find how big the question is that we are trying to answer—What is matter? Well, it is your guess next and perhaps your move, some day.

## MOSQUITOES

Swatting the mosquito becomes a favorite pastime in summer camp if the wind happens to be blowing from near-by marshes or hollows containing stagnant water. However, swatting the mosquito can be much decreased as a pastime if we know the habits and characteristics of this insect. To combat an insect that is particularly annoying we must know its structure and its life habits or life history, as well as its natural enemies, so that the natural enemies may be protected from harm and also that their work may be supplemented by such artificial methods as man will find effective.

The mosquito is said to have a complete metamorphosis—to undergo a complete change in appearance from the time it is born until it dies. For example, the frog, although not an insect, has two distinct stages: the tadpole, which cannot breathe out of water, has no legs, but has a tail, and the frog, which cannot breathe long under water, has four legs, and no tail. Similarly, the mosquito has three distinct stages in its development besides the egg stage—the larva, pupa, and adult.

The eggs must be laid in water if they are to hatch. Some of the eggs remain over winter, but usually those laid in summer hatch in from 36 to 48 hours, depending upon the temperature. The larva or wriggler, as it is commonly called, which hatches from the egg, has a wide and flattened head with large eyes situated on the sides and a pair of short antennæ or feelers on the front of the head. It lives in water, but must come to the surface to breathe, for which purpose it is provided on the eighth abdominal segment with a breathing tube which opens into a system of hollow tubes running into all parts of the body. This system of tubes is known as the tracheal system and supplies the larva with the necessary oxygen. However, it must be remembered that if the larva wants to breathe it must come to the top of the water and thrust its breathing tube through the surface into the air above.

Some wrigglers live on other aquatic insects, and must therefore be provided with mouth parts that permit the catching and holding of its prey; other wrigglers keep up a constant current of water flowing into the mouth from which they strain the small one-celled animals and plants that are washed in with the water. The larva grows rapidly for a few days and then its outer skin becomes firm and inelastic, but under this outer skin another skin is forming which will serve as the outer covering as soon as the old skin is cast off. This casting off of one skin and taking on of another in the process of growth is known as molting and occurs four times during the one, two, or three weeks of larval life. With the fourth molt the insect becomes a non-feeding pupa, resting just below the surface of the water and breathing through

two trumpet shaped tubes on the back of the thorax. This stage lasts from two to six days, depending upon the temperature.

Finally there appears on the surface of the water resting on the cast-off shell or hard skin of the pupa, an insect with two pairs of wings, three pairs of long legs, a long proboscis or beak extending from the front of the head, and a pair of antennæ or feelers. This is the familiar adult mosquito. It rests on the surface of the water for several minutes waiting for its wings to harden so that they can be used in flight. During these minutes it is helpless and often becomes the prey for its enemies.

It is commonly thought that all mosquitoes will bite human beings, but this is not true. The old saying that "the female of the species is more deadly than the male" is literally true among mosquitoes, for the male does not live on human blood but sucks the sap of plants instead. The female can readily be distinguished from the male by the difference in antennæ. The antennæ of the female are slender and thread-like, whereas those of the male are feathery in appearance.

What happens when the mosquito bites your hand? "He's a dead mosquito," you'll say. Yes, but it is claimed that the after effects will not be so severe if you let him finish his meal, for if he finishes his sucking he will draw back into his own system the poison which causes the irritation on your skin. When the mosquito bites he thrusts six little needles into the skin and then pours out a secretion from his salivary glands which is needed to keep the blood from coagulating or thickening while it passes up through the slender hollow needles. The sore which is left is caused by the irritation from this saliva, and will continue to cause annoyance until it has been entirely absorbed and counteracted by the blood. This often takes more than an hour, and with some people a whole day.

Fortunately, the mosquito has certain natural enemies. During the larval stage it is likely to be eaten by the larva of the dragon fly, which also lives in the water, by such beetles as the whirligig, the backswimmers, etc. Fishes also seem to be fond of it for food. So effective, in fact, has a certain minnow become in exterminating the larva of the mosquito that large quantities of minnows are raised yearly to be placed in shallow inlets and pools which form breeding places for the mosquito. During the adult stage, birds, spiders, and toads are classed among its natural enemies besides the dragon fly, which is sometimes spoken of as the mosquito hawk.

However, the most effective campaign to wage against this pest is during its larval stage, for then it is better possible to locate him and provide natural enemies which will destroy all the larvæ. This is also true when we try to employ artificial means to destroy the insect. Swatting is a slow and uncertain means of destroying the pest; smearing oil of pennyroyal or oil of tar on the face and hands is almost a case in which the "cure is worse than the disease"; and using oil of citronella to keep him away has only temporary effects for as soon as the odor of the citronella has evaporated the mosquito returns for an even more hearty meal for he is more hungry. However, a great deal of good has been done by taking advantage of the fact that the larva and pupa both living in water must breathe by coming to the surface, for it has been found that placing a thin coat of oil on the surface will clog up the

air passages and prevent it from breathing. The cheapest and most effective artificial means of killing the mosquito, therefore, is to spray a thin coat of kerosene on water which will be a likely habitat for the larva. Of course, a great deal can be accomplished by seeing that no water accumulates in a place where it will not run away itself. Emptying rain barrels, water troughs, and other containers of water, as well as draining stagnant pools has proven very effective in the fight against the insect in many of the sea border states of the East, particularly in New Jersey.

But much is still to be done, so that constantly scientists are on the alert for natural enemies of the mosquito which can be raised in large numbers, or for artificial means which will prove more effective than those now known.

## TEST COVERING "FACTORS AFFECTING STUDY"

1. It is well to devote as much as half of one's time to practicing recall when trying to memorize significant material.

2. Memorizing brings very much better results if one has a strong intention to remember when he studies.

3. Foreign words (Latin or French) can be best remembered if an attempt is made to learn them in the first place by associating the word with previously known words or facts.

4. It is more economical to memorize a poem of five stanzas by learning it as a whole than by learning a stanza at a time.

5. Themes should be read over aloud before they are handed to the teacher.

6. It is a great mistake to expect to finish writing a theme in one sitting.

7. It is not well to depend on "inspirations" as the means of getting material for a theme.

8. It is not well to study two wholly different subjects following each other without a brief period between them.

9. Some people think that study impressions can be fixed by short rest periods during which the mind is fallow (not active). This, however, has been proven to be untrue.

10. Facts once well learned are likely to be retained without much loss for about a week.

11. It is better to study a lesson thoroughly in one sitting than to distribute the learning over several short periods of time.

12. Overlearning is not usually efficient—it is a waste of time.

13. If facts are memorized for immediate recall they are also likely to be remembered for a much longer time.

14. Writing facts on paper does not materially help in remembering them.

15. If one remembers facts best when they are heard rather than seen, he should try to overcome this habit and develop in its place a memory for things which are seen.

16. It is not well to study out loud when reading a Latin or French sentence, because of a possible mispronunciation of new words.

17. As soon as a new Latin or French word is encountered in a translation it should be looked up in the vocabulary.

18. One reason why the meaning of a Latin or French word is soon forgotten is that the pupil fails to get a clear impression of its meaning the first time.

19. The quality of the impression of a fact determines the effectiveness with which the fact will be remembered.

20. Cramming as a method of study is always bad.

21. Each pupil should develop a speed of reading best fitted for his ability and then retain this speed as nearly as possible for all his future reading.

22. When the reader has found the statement of a principal thought in a lesson it is well for him to express it to himself in one terse sentence using his own rather than the author's words.

23. One of the chief values which comes from outlining a lesson is in the thinking required to organize the facts contained therein.

24. Lessons in history, science, and the like should usually be outlined to insure thorough study.

25. Reading for the purpose of studying can best be done by first studying each sentence and paragraph to determine the facts contained therein.

26. There is no particular advantage in reading the concluding paragraph of a lesson before studying the lesson thoroughly.

27. Outlining serves as one of the best methods of reviewing for an examination.

28. An article or lesson should usually be read thoroughly once as the first step in its study.

29. Hurried reading means careless reading.

30. Skimming is careful reading by paragraphs or other large units of thought.

31. The purpose of skimming is to select the main units of thought.

32. No concern should usually be given to details during the first reading of a lesson like history or science.

33. It is usually easy to place the introductory sentence or paragraph into an outline.

34. The introductory statement should usually be read in more detail than much of the remainder of a lesson during the first reading.

35. Everything that is said in an article to be outlined should find a place in the outline.

36. The introductory paragraph hardly ever gives a clue to the main points in the article.

37. A paragraph can invariably be depended on as containing a separate main point.

38. The introductory statement of an article may simply serve as a connection between it and something which has been said previously.

39. When skimming one's sole purpose should be to get into mind what are the main points discussed.

40. A lesson can usually be read with intelligence and efficiency if read with care and thoroughness the first time.

41. As soon as one has skimmed an article he should write down the main points which he found in his reading.

42. Whenever possible, avoid using the wording of the article as the wording used in the statement of the main points.

43. Reading by paragraphs means reading just enough of each paragraph to know the main point discussed in it.

44. When beginning the study of an advance lesson in history or science very little value comes from trying to recall the contents of the preceding lesson; it is better to begin the advance lesson immediately.

45. When trying to memorize conjugations or declensions in a foreign language it is better to distribute the effort over two or three periods of time rather than try for final thoroughness in one sitting.

46. As a final preparation in Latin or French it is well to translate the lesson aloud.

*Questions 47 to 68 apply to the solution of originals in geometry.*

47. One should be able to visualize the completed figure (have a mental picture of it) before he actually begins to draw any part of it.

48. The meanings of all significant words in a theorem should be looked up, if not already known, before drawing the figure.

49. When the theorem is read for the first time no more care of detail need be taken than just enough to be able to select that part of it which deals with what is given, and that part which deals with what is to be proved.

50. If drawing the figure involves difficulties it is well first to select from the theorem those separate words or phrases which represent separate drawing operations.

51. After having thus selected separate drawing operations a mental picture of the completed figure should be formed before attempting to make any drawing.

52. The figure drawn should always be as regular as possible—for example, unless otherwise stated an isosceles triangle should be drawn when a triangle is called for, etc.

53. It is well to depend upon "looks" (how a figure appears to be drawn) when trying to prove certain relationships.

54. Drawing a figure with care will often help in showing certain relationships which will be helpful in proving the original.

55. As soon as the figure has been drawn one should always write out the proof.

56. One should examine the figure with care in order to select those things which are true either because of what is given or because of what follows directly from the "given."

57. One must also select in terms of the figure the things which is to be proved.

58. No scheme can be followed in trying to prove the original from this point, but one must instead depend entirely on chance as to whether he thinks of the correct steps to select.

59. If a construction line has to be drawn to finish the proof one must depend entirely on trial and error in determining where to draw the line (that is, one drawing must be tried and if that doesn't work another one must be tried, etc. No particular plan can guide one's selection).

60. Before drawing the figure for the original, one should have pretty clearly in mind the general plan to be followed in proving it.

61. After drawing the figure and before actually writing any proof on paper, a plan of proof should be determined upon.

62. When one is faced with the difficulty of proving a particular step (lines equal, lines proportional, or the like) all the conditions under which this fact can be proved true should be summoned to mind and the one selected which best fits the case.

63. Before actually writing out any proof one should analyze the facts at hand, beginning with what is to be proved, and reasoning out conditions under which this can be done, until in his reasoning he comes to what is given.

64. Being able to call to mind all the conditions under which a certain fact can be proved is an important thing in trying to prove originals.

65. The plan for proving originals is very different from that to be used for proving propositions in the correct manner.

66. What is actually put on paper as the proof of an original is about in the reverse order of the method used in determining how it should be proved.

67. The secret of success in proving an original lies in the ability to "hit upon" the correct reference to be used, and no plan of procedure can help one, therefore, to improve in this ability.

68. When an original has once been successfully proved its proof should be carefully memorized for future use.

*Questions 69 to 92 apply to reviewing for an examination in science.*

69. It is sufficient to leaf through the book and try to recall facts as they appear and study those which seem difficult.

70. Reviewing for an examination is not much help, provided one has studied his lessons faithfully from day to day.

71. If one has not studied his lessons faithfully from day to day it is possible to get a good deal of very worthwhile knowledge by a rapid review a short time before an examination.

72. If the names of several scientists appear in the work to be reviewed one should select out these names and associate with each the achievement credited to him.

73. All one needs to do is to make an outline covering the subject matter to be included in the examination.

74. One should study all facts with equal thoroughness.

75. One need not give much concern to diagrams, pictures, etc., which appear on the pages included in the examination.

76. It is well to make a list of the most difficult scientific terms and recall their meanings.

77. It is always safest to assume that all the material to be covered is of equal importance.

78. One can study for the examination a good deal more efficiently if he tries to anticipate the kind of questions which are likely to be asked.

79. List all important appliances or pieces of apparatus or machinery mentioned in the part to be reviewed and associate with each the important scientific principle which makes it possible.

80. Bring together words which resemble each other in sound or appearance and distinguish between them in meaning.

81. There is very little value in using the index to recall the meanings of new terms which should be known.

82. No attempt need be made to organize the material under a few main divisions.

83. Textbooks in general science are so well organized that one needs only to use the author's paragraph and section headings as the best division of the subject matter for examination review.

84. Reviewing a detailed diagram of an important piece of apparatus is of little or no value for reviewing for an examination.

85. If two new words used to explain different scientific facts either look or sound alike they should be associated and studied together when reviewing for an examination, even though they refer to wholly different things or ideas (Example, anemometer, ammeter).

86. If two pieces of apparatus closely resemble each other, but the principles of operation are wholly different, there is an advantage in studying these together. (Example, dynamo, motor).

87. It is well to associate in the reviewing instruments used in measuring, phenomena or forces, even though these are widely different. (Example, thermometer measures temperature, voltmeter measures volts, etc.).

88. It is well to study bits of apparatus together and associate with each the scientific principle on which its usefulness depends.

89. Outlining all the work covered during the month or year included by the examination will serve as an excellent help in recalling those facts which are important.

90. Notes taken in class need not be included in the review.

91. Being afraid that one may not pass is not a help in preparing for an examination, but rather a hindrance.

92. It is not best to review for a rather long examination in one sitting. It is better to spread it over a few days and make a hurried review of the "high spots" after having finished the careful review of the whole.

*Questions 93 to 105 apply to review for an examination in geometry.*

93. Reviewing for an examination involves a reorganization of facts already learned.

94. In reviewing for an examination it is best to restudy the facts in the order in which they were taken up in class originally.

95. In reviewing for an examination in geometry one should study all propositions equally well.

96. One should recall all the methods of proving lines equal, angle equal, etc.

97. One should collect from the several parts of the work to be covered, all formulæ and equations which represent relationships between figures (areas, volumes, similarity, etc.), and study them in this new association.

98. One should divide all of the propositions into groups representing the probability of having them in the examination.

99. It is well to try to anticipate the kind of examination question which will be given.

100. It is not necessary to place emphasis on the recall of construction lines that must be drawn to prove different propositions.

101. There is no particular value in using the index of the book to review new terms which should be known.

102. Trying to recall the key reference to references on which the proof of a proposition or corollary depends is a good quick way of assuring oneself that he can prove the proposition.

103. Some propositions and corollaries need to be reviewed only sufficiently to know what they mean so that they can be used as a reference in proving other propositions or corollaries.

104. An effort should be made to memorize the proof of propositions which are considered important.

105. Reviewing for an examination in geometry is not important if *there has been a conscientious daily preparation* of lessons.

106. Habits of study which are easily made are also easily broken.

107. If one wants to break a poor habit of study and develop a good habit in its place one need only to assert a will to make the change if he would be successful.

108. One can always depend on the method of studying which at first is easiest to be the one which will be the best in the end.

109. One should try to perform the least possible number of acts habitually, but should, instead, replace habits by reason whenever possible.

110. Notes which are taken in class should not be the words of the speaker, but rather his thought expressed in one's own words.

111. Notes taken in class should be looked over and elaborated (mentally) just as soon after the class period as possible.

112. Diagrams in notes often serve as a help in fixing material that is received from lectures.

113. When reading for the purpose of studying, it is well to adopt a questioning attitude rather than accept without question everything that the author says.

114. Habits of reading are so well fixed by the time one reaches high school that it is not well to try to change them after reaching high school.

115. Reading an article for appreciation does not require a method of reading which is essentially different from reading for the purpose of study.

116. "Reading between the lines," that is, supplementing an author's statements by one's own ideas, is often necessary to get the best out of one's reading.